THE ESTIMATION OF THE COST OF CAPITAL FOR SUBSIDIARIES OF PUBLIC UTILITY HOLDING COMPANIES

BY

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To Susan and Shonali

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The conventional cost of capital models like the Discounted Cash Flow (DCF) model and the Capital Asset Pricing Model (CAPM) are expressed in terms of the prices of financial assets. Their implementation, therefore, depends on the availability of capital market data. This limits their direct application to the estimation of capital costs of firms whose stocks and bonds are traded in the capital market. However, to make value-maximizing investment decisions and "fair" regulatory decisions there is often the need to estimate the cost of capital of a firm's projects, divisions and subsidiaries, entities that are not traded in the capital markets. In this study we develop and critically evaluate alternative methodologies for estimating the capital costs of subsidiary firms. We apply these methodologies to estimate the cost of equity of electric utility subsidiaries, telephone subsidiaries, and Western Electric Company, an unregulated subsidiary of a regulated parent company, AT&T.

We follow two basic approaches to estimate the subsidiary capital costs. In the analogy or pure-play approach we identify a group of traded firms with risk comparable to that of the subsidiary being analyzed. The subsidiary capital cost is then the average of the capital costs of the firms in the comparable risk group. In the analytical approach we estimate, econometrically, the relationship between risk/return and their real or fundamental determinants which can be measured from firm data. We developed four econometric models based on (1) real determinants of equity cost, (2) the Gordon Valuation equation, (3) the CAPM equation and (4) the theory of the firm. We conclude that the two most viable approaches are the analogy approach and the analytical approach based on the Gordon Valuation equation. In the latter approach, in addition to estimating equity cost we can also estimate the market value of equity of the subsidiaries. This permits us to test for the validity of our estimates under the assumption of Value Additivity. We compare the equity cost of the traded parent to the weighted sum of the estimated costs of the non-traded subsidiaries, the weights being the equity market value fractions.

CHAPTER I
INTRODUCTION

The value-maximizing set of investment alternatives depends upon the market's required rate of return on the funds used to finance each alternative investment. It is therefore critically important that a firm be able to estimate the required rate of return (or cost of capital) for each of its projects, divisions, and subsidiaries. The most generally accepted techniques for estimating the cost of capital are based on the Discounted Cash Flow (DCF) model and the Capital Asset Pricing Model (CAPM). In their operational form, these models are expressed in terms of the prices of financial assets. In the CAPM, the market-determined required rate of return is a linear function of the relevant risk which is estimated as the covariance between the firm's market rate of return and the return on the market portfolio. In the DCF model, the cost of capital is estimated as the sum of the dividend yield and the expected capital gains yield, both expressed in terms of stock prices.

To use either the DCF model or the CAPM, we need capital market data; therefore, their direct application is necessarily limited to the estimation of capital costs of firms traded in the capital market. Moreover, the estimate of a traded firm's overall cost of capital cannot be directly used to make value-maximizing investment decisions unless it can be assumed that all of its projects, divisions and subsidiaries are of equal risk. If this assumption is not valid, but nevertheless a single hurdle rate--the firm's cost of capital--is used to make investment decisions, there will be a misallocation of resources, and shareholder wealth would not be maximized. Therefore, what we need are unique estimates of the required rates of return for projects, divisions, and subsidiaries, where each required return is commensurate with an individual investment's risk. However, since these investments are not traded in the capital markets, the absence of capital market data presents an obvious problem in the direct application of the conventional estimation techniques based on the DCF model and the CAPM.

For a regulated firm such as a public utility, the "fair" rate of return that the Regulatory Commission "allows" it to earn is based upon estimated capital costs for the utility. When commissions have to set "fair" rates of returns and prices for subsidiaries of holding companies, they are faced with the problem of determining capital costs in the absence of capital market data. In regulatory proceedings this problem is usually circumvented by assuming that the subsidiary companies have the same risk characteristics, and therefore the same cost of capital, as the parent company as determined from capital market data. This assumption may not always be valid. To the extent that it is not, the assignment of the same cost of capital to all subsidiaries will lead to resource misallocation and the subsidization of the customers of the higher-risk subsidiary by the customers of the lower-risk subsidiary.

It is apparent from the above discussion that, whereas cost of capital models have been made operational for firms traded in the capital markets, there is still a pressing need in business finance and regulation for techniques to estimate the capital costs of both individual non-traded assets and subsidiary firms. The major purpose of this study is to explore various techniques for making these estimates.

First, it is shown that the conceptually correct technique for estimating the cost of capital of a subsidiary firm is the so-called subsidiary approach, in which each subsidiary is treated as an independent entity with its own unique risk characteristics. The required rate of return for the subsidiary is then found as a function of its risk. Within this framework there are two possible approaches. One is the analogy, or "pure play," approach, in which the cost of capital of the subsidiary is estimated to be the average cost of capital of a group of "comparable risk firms" whose stocks are traded in the capital markets. The cost of capital for the comparable group can be estimated using either market model--the DCF or CAPM. The second approach is the analytical approach in which risk is defined not in terms of the financial variables based on capital market data, but in terms of "real" or fundamental variables that can be estimated from the firm's accounting data. A relationship is established between returns and the real determinants of risk, and from this relationship the cost of capital of the subsidiary can be directly estimated.

As noted above, the primary objective of this study is to develop and to evaluate critically the alternative approaches to estimating the cost of capital of subsidiary firms and then to recommend the best approach. The improved estimation of subsidiary capital costs will help firms make better investment decisions and commissions make better regulatory decisions. A secondary objective of the study is the valuation of subsidiaries, because some of the models developed in the study will allow the estimation of the "market value" of subsidiary firms. This aspect of the study will address the question of corporate synergy by comparing the observed market value of the parent to the sum of the estimated market values of the subsidiaries, assuming they were operating independently.

Although the methodologies developed in the study have general applicability, specific applications will be limited to (1) regulated subsidiaries in the electric utility and the telephone industries and (2) unregulated subsidiaries of a regulated industry (for example, the Western Electric Company, a subsidiary of AT&T).

CHAPTER II
REVIEW OF THE LITERATURE

Introduction

In the literature there are two basic approaches to estimating the cost of capital of subsidiary firms.

The Double Leverage Approach. In this approach the overall weighted average cost of capital of the parent firm is applied to the equity of all the subsidiaries. This approach has conceptual problems which limit its validity to the specific case in which all the subsidiaries are of equal risk.

The Subsidiary Approach. In this approach one regards each subsidiary as a separate entity with a unique cost of capital commensurate with its risk. The difficulty with implementing this approach is that conventional cost of capital models like the Discounted Cash Flow (DCF) and Capital Asset Pricing Model (CAPM) cannot directly be used to estimate the subsidiary cost of capital. These models depend on capital market data which are not available for the non-traded subsidiary firms. However, this approach is conceptually sound and will be the main focus of this study. Within the subsidiary approach there are two methods by which the subsidiary cost of capital can be estimated. One is the analogy or "pure play" approach in which the cost of capital of the subsidiary is estimated to be the average of the capital cost of a sample of comparable-risk traded firms. The most recent study that uses the pure play approach is by Fuller and Kerr (1981). The other subsidiary approach is an analytical approach in which a relationship is established between risk/return and the "real" or fundamental variables whose measurements do not depend on capital market data. From this relationship the capital cost of the non-traded subsidiary can directly be estimated. The earlier studies in this area have been purely empirical in nature attempting to find statistical correlations between market risk and accounting or firm variables. Studies by Ball and Brown (1969), Beaver, Kettler and Scholes (1970), Gonedes (1973), Beaver and Manegold (1975), Barr-Rosenberg and Marathe (1975), Barr-Rosenberg and McKibben (1973) and Sullivan (1978) are representative of this purely empirical approach. Gordon and Halpern (1974) apply this approach to estimate the cost of equity of a division of a firm. More recent studies have attempted to provide a theoretical basis for the relationship between risk/return and the fundamental firm variables. These include studies by Hill and Stone (1980), Subrahmanyam and Thomadakis (1980), Chiang and Goldenberg (1980) and Myers and Turnbull (1977).

Based on this overview we will divide the literature review into the following sections:

1. Studies on the Double Leverage Approach.
2. Studies on the Subsidiary Approach, which will be further subdivided into subsections as follows:
    a. Studies on the Analogy or "Pure Play" Approach.
    b. Studies on the Analytical Approach.

Studies on the Double Leverage Approach

To understand how the Double Leverage Approach works we illustrate its use to estimate the cost of capital of subsidiaries A and B of a parent company P. The simplified balance sheets for the two subsidiaries, parent company, and the consolidated holding company are presented in Tables 2-1 through 2-4.

We assume the following capital cost estimates:

	Estimated Cost
Debt of subsidiary A	10%
Debt of subsidiary B	12
Debt of parent	14
Equity of parent	16

From these capital cost estimates and the balance sheet values, the Double Leverage Approach calculates the weighted average cost for the parent company as an estimate of the cost of equity of the subsidiaries A and B. Thus for the parent company,

	Amount	% of Capital	Cost	Weighted Cost
Debt of parent	$ 50	50%	14%	7%
Equity of parent	50	50	16	8
	$100	100%		15%

The costs of equity for the subsidiaries is then 15 percent and their weighted average or overall capital costs are estimated as follows:

Subsidiary A

	Amount	% of Capital	Cost	Weighted Cost
Debt	$ 40	40%	10%	4%
Equity	60	60	15	9
	$100	100%		13%

Table 2-1
Balance Sheet of Subsidiary A

Assets		Liabilities	
Assets	$100	Debt	$ 40
		Equity	60
Total assets	$100	Total liabilities	$100

Table 2-2
Balance Sheet of Subsidiary B

Assets		Liabilities	
Assets	$100	Debt	$ 60
		Equity	40
Total assets	$100	Total liabilities	$100

Table 2-3
Balance Sheet of Parent Company

Assets		Liabilities	
Equity in A	$ 60	Debt of Parent	$ 50
Equity in B	40	Equity of Parent	50
Total Assets	$100	Total liabilities	$100

Table 2-4
Balance Sheet of Consolidated Holding Company

Assets		Liabilities	
Assets of A	$100	Debt of Parent	$ 50
Assets of B	100	Debt of A	40
		Debt of B	60
		Equity of Parent	50
Total Assets	$200	Total liabilities	$200

Subsidiary B

	Amount	% of Capital	Cost	Weighted Cost
Debt	$ 60	60%	12%	7.2%
Equity	40	40	15	6.0
	$100	100%		13.2%

The major conceptual flaw in this approach is obvious. The same cost of equity (15%) has been applied to subsidiaries A and B, implicitly assuming that they have the same equity risk which may or may not be the case. The required rate of return on a subsidiary should depend exclusively on the riskiness of its assets, as is the case in the Subsidiary Approach, and not on who owns the equity, as is the case in the Double Leverage Approach. In the Double Leverage Approach, if the parent changes its capital structure resulting in a change in its overall cost of capital, the cost of equity of the subsidiary would change although there has been no change in the subsidiary asset risk. Thus a change in the riskiness of the owners (the parent) of the subsidiary has caused a change in the cost of equity of the subsidiary without any change in its asset risk. This is not acceptable in finance theory. The arguments against double leverage have been made by Brennan and Humphreys (1973), Lerner (1973), Rozeff (1981), and Pettway and Jordan (1983).

Studies on the Subsidiary Approach

Analogy or "Pure Play" Approach

Fuller and Kerr (1981). The "pure play" technique, in which proxy measures of market risk and return are obtained for the non-traded division or subsidiary, has been around for a long time. Fuller and

Kerr were the first to attempt to empirically validate this approach. Their study consisted of the following steps:

1. Sixty multidivision firms were chosen with 142 divisions.
2. For each division a pure play firm with publicly traded securities was chosen. The major criteria for the pure play selection were line of business, revenue, and geographical factors. Thus the criteria focus on operating characteristics of the firm and do not consider financial risk.
3. For each pure play firm, a beta value was obtained from Value Line. These beta values were used as proxies for the market risk of the divisions.
4. Invoking the Value Additivity Principle

$$V_j = \Sigma V_{ij} \qquad (2\text{-}1)$$

where

V_j = Market value of the jth multidivision firm

V_{ij} = Market value of the ith division of the jth multidivision firm

and

$$\beta_j = \Sigma(S_{ij}/S_j)\beta_{ij} = \Sigma w_{ij}\beta_{ij} \qquad (2\text{-}2)$$

where

β_j = Systematic risk of the jth multidivision firm

β_{ij} = Systematic risk of the ith division of the jth multidivision firm

S_j = Market value of the equity of the multidivision firm

S_{ij} = Market value of the equity of the ith division of the jth multidivision firm

w_{ij} = Equity value weights

5. As an empirical validation of the pure play technique, Equation (2-2) is tested using the pure-play proxy estimates of the market risk ($\hat{\beta}_{ij}$) of the divisions. In Equation (2-2), the weights $w_{ij} = S_{ij}/S_j$, applied to the division betas, β_{ij}, are market value of equity weights. However, since these values are not observable for divisions, a proxy

$$\hat{w}_{ij} = \frac{\text{Division sales}}{\text{Multidivision firm sales}}$$

was used.

6. The authors found a reasonably close agreement between the observed β_j of the multidivision firms and the weighted average value of the estimated pure play betas of their divisions. A regression of the observed multidivision firm beta, β_j, on the pure play estimate of $\hat{\beta}_j$ produced an R^2 value of 0.78.

7. As a final part of their analysis the authors attempt to adjust for leverage. Since the pure play firms were chosen without consideration of leverage, an adjustment is made in which the estimated equity betas, β_{ij}, are unlevered using the Hamada (1972) equation and the divisional capital structure, proxied by the pure play firm's capital structure, and then relevered using the multidivision capital structure to obtain an adjusted beta, $\beta_{ij}{}^{a}$. Both market value and book value capital structures were used. The agreement between the multidivision betas and the weighted average proxy betas was not as good with adjusted betas as with unadjusted betas. The R^2 value dropped from 0.78 with unadjusted betas to

0.44 with adjusted betas using book value ratio of leverage. The fit was significantly inferior with market value leverage.

The main contribution of the Fuller and Kerr study is its attempt to empirically validate the pure play technique. However, there are several problems with their study.

1. The testable hypothesis in the study is that the observed beta values of the multidivision firm are not significantly different from the weighted average value of the betas of the divisions estimated by the pure play technique. The weights applied to the division betas should, theoretically, from the Value Additivity Principle be market value of equity weights. However, since the market value of equity of divisions are not observable, the authors use fraction of division sales to total firm sales as a proxy. This approximation may not be appropriate. If it were, then the complex problem of valuation of subsidiaries and divisions could directly be solved as

$$V_{ij} = \frac{\text{Divisional sales}}{\text{Total sales}}(V_j) \qquad (2\text{-}3)$$

   In our study we will develop a model which allows estimation of equity costs *and* market value of equity for the non-traded firm, making the value-additivity test more valid.

2. The pure play firms were chosen without matching financial risk. Yet their results show that divisional betas, unadjusted for differences between the division's and the pure-play's capital structure, provide better estimates of the multidivision firm's beta

than did leverage-adjusted beta. This result suggests that differences between the division's and pure play's leverage can be disregarded. This result is difficult to accept given the general recognition that risk and leverage are related.

Studies on the Analytical Approach

Ball and Brown (1969). This study is one of the early attempts to find a relationship between market risk and accounting variables. Ball and Brown carry out time series regressions of various accounting numbers of firms on the corresponding accounting numbers for the market index and compute the coefficients of determination, R_i^2. They repeat the analysis regressing the firm's market rate of return on the rate of return on the market index and estimate $(R_i)_m^2$. The R_i^2 values are measures of co-movement of the firm's and the market's accounting earnings and therefore indirect measures of the firms' accounting betas. The $(R_i)_m^2$ values are assumed to be measures of the firm's market betas. Ball and Brown then estimate the product correlation and rank-order correlation coefficients between R_i^2 and $(R_i)_m^2$. These correlation coefficients are measures of the ability of the accounting variable to predict systematic market risk. The study used time series data over the period 1946-1966 for a sample of 261 firms. The following accounting numbers were used in the regression:

1. Level of operating income, NOI.
2. First difference in operating income, ΔNOI.
3. Level of net income, NI.

4. First difference in net income, ΔNI.
5. Earnings per share, EPS.
6. First difference in earnings per share, ΔEPS.

Correlations were higher with first differences in the accounting numbers than with levels and the highest correlation (0.47) was obtained with income defined as operating income. Ball and Brown then repeated the analysis with all the accounting variables normalized by dividing by the market value of equity. The correlation coefficients were higher with the normalized variables.

The study does not provide any theoretical basis for the relationship between accounting numbers and the market risk. Also the statistical techniques are not particularly sophisticated. However, the study is important in that it represents one of the earliest attempts to relate systematic risk to fundamental firm variables.

Beaver, Kettler, and Scholes (1970). This study confirms the results of Ball and Brown and extends the analysis to examine the association between systematic risk and seven accounting variables each taken separately. The seven variable chosen were as follows:

1. Dividend payout: measured as a nine-year historical average. The authors (BKS) present two arguments for including dividend payout rate as a risk determinant. First, firms are reluctant to cut dividends and maintain a level of dividends that can be covered by long-term earnings. A low dividend payout rate therefore reflects management's uncertainty about future earnings. Second, low payout

rate reflects higher retention and growth. Traditionally high growth is associated with high risk. A priori, dividend payout rate is expected to be inversely related to risk.

2. Growth: measured as the log of the 5 year change in book assets. High growth is associated with high business risk.
3. Financial leverage: measured as the book value of debt to total assets. There is a theoretical basis for including financial leverage as a risk determinant. Hamada (1972) has shown that there is a positive relationship between stock beta and leverage measured in market value terms.
4. Size: measured as log of net book assets. Size is expected to reflect diversification and therefore is hypothesized to be inversely related to risk.
5. Earnings variability: measured as the standard deviation of earnings over 9 years. Each year's net earnings available to shareholders is normalized by dividing by the market value of equity at the end of the preceding year. High earnings volatility is expected to be associated with high price volatility and total risk.
6. Liquidity: measured as the firm's current ratio. The lower this ratio is, the higher the solvency risk.
7. Earnings beta: measured as the slope coefficient of the regression of the firm's net earnings on the average earnings for a market index. Again earnings are normalized by dividing by the previous period's stock value. Since stock prices respond to earnings, earnings beta and market beta are expected to be positively correlated.

BKS tested for the association between the market beta and the seven accounting variables, each considered separately, for a sample of 307 firms for the period 1947-65. They split the data into two subperiods, 1947-56 and 1957-65. Within each subperiod they carried out correlation tests on individual securities and on portfolios of five securities formed by ranking the stocks on the basis of the relevant accounting variables. The results showed that leverage, earnings beta, dividend payout rate and earnings variability were significantly correlated with market beta in the expected direction, in both subperiods. BKS then attempted to predict betas for the period 1957-65, from an estimated multiple regression equation for the subperiod 1947-56. The prediction was poor explaining only 24 percent of the variance of the betas during 1957-65. A naive prediction which assumes that the betas would remain unchanged from 1947-56 to 1957-65 explained 21 percent of the beta variance.

Of the seven variables tested as possible determinants of systematic risk, a theoretical basis exists for the selection of only the financial leverage variable. Accounting beta is a plausible candidate as a determinant of systematic risk. Since stock prices do respond to earnings it is reasonable to expect that co-movement of the firm's earnings with the earnings of the market will be correlated with the co-movement of the firm's stock returns with the market returns. All the other variables are likely to be determinants of total risk rather than systematic risk. The BKS results that stock betas are significantly correlated with leverage and earnings beta is consistent with theory. However they also find beta to be correlated with earnings variability which represents total rather than systematic risk of earnings. Another problem with this study, especially as it relates to the problem of estimating capital cost in the absence of capital market data, is that the earnings beta are not purely based on the firm's accounting data. BKS normalize the net earnings to shareholders by market value of equity in their beta estimation, thus obtaining an earnings-price beta which requires capital market data.

Gonedes (1973). Gonedes tested for the correlation between accounting beta and market beta using the following accounting measures:

1. Net income, NI.
2. First difference in net income, ΔNI.
3. Net income normalized by net book assets, i.e., return on assets, NI/asset.
4. First difference in normalized net income, $\Delta(\frac{NI}{Assets})$

Working with a sample of 99 firms over three 7-year subperiods between 1946-67, Gonedes found results that contradicted the BKS results. He found no significant correlation between accounting betas based on return on assets and market betas, for any of the subperiods. Like Ball and Brown (1969), Gonedes also tested for the correlation between the R^2 values of the time series regressions for estimating accounting beta and market beta. He found the relationship to be significant when accounting returns were defined in terms of first differences.

Gonedes attributed the significant association between accounting and market betas obtained by BKS, to spurious correlation. He argues that spurious correlation arises because the stock price or market value of equity appears as the deflator in the estimation equations for both the accounting beta and market beta.

Beaver and Manegold (1975). In the most comprehensive study on the association between accounting and market betas, Beaver and Manegold reject the Gonedes argument and demonstrate that his negative findings were due to severe problems in measurement. In fact the Beaver and Manegold study is aimed at improving measurements of accounting and market betas. To the extent that measurement errors exist in betas, correlations between accounting and market betas will be downward biased. Beaver and Manegold take the following steps to reduce measurement errors in accounting and market betas:

1. Aggregate individual security betas into portfolio betas: the aggregation involves a tradeoff between reduced measurement error and loss of information or increased sampling error. Beaver and Manegold aggregate on the basis of market beta, the dependent variable.
2. Use a Bayesian adjustment procedure developed by Vasichek (1973): the observed betas are adjusted toward the mean of the cross-sectional distribution of betas, that is, adjusted toward a value of 1.0.
3. Appropriate measurement of accounting returns: the problem of the appropriate definition of returns is relevant only to estimation of accounting betas. Ball and Brown and BKS deflated net income to shareholders by market value of common equity while Gonedes used

total assets. The advantage of using market value of equity as the deflator is that it is a more accurate assessment of the investment base and can be measured without significant error. The disadvantage is that the beta obtained from this definition of return is not a pure accounting beta. It uses market data which, in the context of our study, is not available. Gonedes' use of total assets as the denominator produces returns for the entire firm rather than returns to the equity portion. Since market beta is a measure of equity risk, accounting beta should be measured from time-series of returns on book equity. Beaver and Manegold use all three return measures in their study--return on market value of equity, return on total assets and return on book equity.

4. Correction for autocorrelation: again this is a problem specific to the measurement of accounting betas only. In the presence of autocorrelation the estimators are inefficient and their standard error downward biased. Beaver and Manegold correct for autocorrelation by using, like Ball and Brown and BKS, first differences in their three measures of returns and by the Standard Durbin method.
5. Reduction in sampling error: the sampling error can be reduced by increasing the number of observations. This can be a problem with accounting betas where returns are estimated from annual observations. Increasing the estimation horizon assumes a stable distribution of returns over a longer period. To study the impact of estimation horizon the authors computed accounting beta for three time periods: a total periods 1951-69 and two subperiods, 1951-60 and 1961-69.

Beaver and Manegold carried out their tests on a sample of 254 Industrial, New York Stock Exchange firms with fiscal year end of December 31. Accounting and market betas were estimated as the slope coefficient, b_i, of the time series regression

$$R_{it} = a_i + b_i R_{mt} + e_{it} \tag{2-4}$$

The returns were measured in the logarithmic form. Thus for market betas, monthly returns for the firms were measured as

$$R_{it} = \ln \frac{D_{it} + P_{it}}{P_{it-1}} \tag{2-5}$$

and the market return as

$$R_{mt} = \ln \frac{M_t}{M_{t-1}} \tag{2-6}$$

where M_t is the value of the equally weighted market index. To estimate accounting beta the returns were measured as

$$R_{it} = \ln(1 + R_{it}') \tag{2-7}$$

and

$$R_{mt} = \ln(1 + R_{mt}') \tag{2-8}$$

where R_{it}' is the accounting return computed with annual data and defined alternatively as

$$\text{Return on market value of equity} = \frac{E}{P} = \frac{\text{Net income}}{\text{Market value of equity}} = \frac{NI}{MV}$$

$$\text{Return on assets} = \frac{\text{Net income}}{\text{Total assets}} = \frac{NI}{TA}$$

$$\text{Return on book equity} = \frac{\text{Net income}}{\text{Book value of equity}} = \frac{NI}{BV}$$

R_{mt}' is the accounting return on the market index defined as

$$R_{mt}' = \frac{1}{254} \sum_{i=1}^{254} R_{it}' \qquad (2\text{-}9)$$

The accounting and market betas were estimated with and without the various adjustments to reduce measurement errors and the correlation coefficient among them were tested for the total period and the two subperiods. The major results of the Beaver-Manegold study are as follows:

1. Even without any kind of correction for measurement errors there is a statistically significant correlation between accounting and market betas for all definitions of accounting returns. However for the total period accounting betas account for only 15 to 20 percent of the variation in market betas.
2. With aggregation, the R^2 values increase but the significance or t-values of the slope coefficients decline. This is because of the higher standard error in estimation of the regression coefficient resulting from the loss of information through aggregation.
3. Bayesian adjustments consistently improved the correlation between accounting and market betas.
4. NI/MV betas had the highest correlation followed by NI/BV betas and NI/TA betas in that order.

5. Correction for autocorrelation, either by first difference or the Durbin method, did not result in any significant improvement in the correlations.
6. Total period accounting betas produced higher correlation than betas estimated for either subperiod.

Finally Beaver and Manegold applied their methodology to the Gonedes sample and found the correlations to be significant, contradicting Gonedes' results. They conclude that Gonedes' results were due to severe measurement errors in his beta estimates.

The Beaver and Manegold study is, to date, the most comprehensive and thorough empirical study on the association between market risk and one of its real determinants, the accounting beta. The study conclusively proves that accounting beta is a significant determinant of market beta. However, the accounting beta explains only a small portion of the total variation in market betas implying that there are other relevant explanatory variables for market betas. If this is the case, the Beaver-Manegold study may have omitted variable problems which could cloud their results.

Barr-Rosenberg and McKibben (1973). The correlation tests carried out in all the studies discussed so far proceeded in two stages. The first stage used time series data for each firm in the sample to estimate the dependent variable--the market beta--and the independent variables--the accounting beta and other fundamental variables. In the second stage correlations between the market beta and its real determinants were estimated in a cross-sectional analysis. This two-stage approach implicitly assumes that the variables are stable across time for each firm but that cross-sectional variance exists for these variables across firms. This assumption may not be valid. The determinants of beta could vary across time in which case beta also would be time dependent. Rosenberg and McKibben devised a methodology that explicitly allowed for beta changes over time. They specify beta at time t to be linearly related to certain real determinants W_{nt}. For firm j

$$\beta_{jt} = \sum_{n=1}^{N} W_{jnt} b_j + \varepsilon_j ; \; N = \text{number of beta determinants}$$

This specification of β_{jt} is substituted in the market model

$$R_{jt} = \alpha + \beta_{jt} r_{mt} + \eta_{jt} \tag{2-10}$$

yielding

$$R_{jt} = \alpha + \sum_{n=1}^{N} b_j (W_{jnt} r_{mt}) + (\varepsilon_j r_{mt} + \eta_{jt})$$

$$= \alpha + \sum_{n=1}^{N} b_j (W_{jnt} r_{mt}) + u_{jt} \tag{2-11}$$

The independent variables are the product of the hypothesized real determinants and the market returns. We now have a one-step procedure in which the coefficient b_j estimates the correlation between market beta and its real determinants, allowing both sets of variables to change over time.

Rosenberg and McKibben tested the model on a sample of 558 firms over the period 1954-66. They used 32 explanatory variables including accounting variables like accounting beta, and market variables like historical beta, residual risk in the market model, earnings-price ratio. Consistent with earlier studies they found financial leverage, earnings volatility and growth in sales and earnings to be significant determinants of beta. However, they found accounting beta and dividend payout rate to be insignificant, contrary to earlier findings.

There are two major problems with this study. First, with 32 explanatory variables the probability of multicollinearity distorting the relationships between beta and its determinants is extremely high. Secondly, given the model specification the use of ordinary least squares (OLS) regression is not appropriate. The error-term $u_{jt} = \varepsilon_j r_{mt} + \eta_{jt}$ is a function of the explanatory variable r_{mt} in violation of the OLS assumption. The coefficients are likely to be biased and inconsistent.

Barr-Rosenberg and Marathe (1975). In this later study the authors corrected for some of the econometric problems by running generalized least squares (GLS) regression. The model still included a very large number of market variables and accounting variables, often with multiple measures proxying for a single variable. For example, variances in earnings and in cash flow were used to measure earnings variability. Financial leverage was measured by market value and book value ratios. They found results that were inconsistent with theory. The market value leverage coefficient was significant and negative but the book value leverage coefficient was positive and significant. Growth in EPS was negatively related to beta but growth in assets was positively related. The authors fail to explain these discrepancies.

Sullivan (1978). So far, the studies reviewed have related market risk/return to the accounting variables of the firm. Sullivan attempts to relate systematic risk to the structure of the output market. Specifically he examines, empirically, the impact of the market power of a firm on its systematic risk, hence cost of capital. For a cross section of firms in 1972, he ran a regression of betas, both levered and unlevered, on the following variables:

1. SZ_j = $\ln[\text{Sales}]_{1972}$; a measure of absolute market power.
2. C_j = the four-firm concentration ratio in 1972 for the primary market of firm j; a measure of relative market power.
3. SG_j = compound annual growth rate in sales from 1963 to 1972; a control variable.
4. DN_j = a dummy control variable; DN_j = 1.0 for durable goods, DN_j = 0 for nondurable goods.

Sullivan found the coefficients of both the absolute and relative measures of market power to be significant and negative. Firms with higher market power have lower systematic risk and cost of capital.

Sullivan's study establishes empirically that market power is a determinant of systematic risk and cost of capital. However, beyond speculating that more powerful firms may have lower risk because they may be better able to react to social, economic and political changes, the study does not provide a theory linking market power to risk. Such a theory was provided later by Subrahmanyam and Thomadakis (1980), who related systematic risk to the theory of the firm.

Gordon and Halpern (1974). This study demonstrates the use of the relationship between market beta and accounting beta to estimate the cost of capital of a division of a firm. In the CAPM framework,

$$k_j = R_F + \beta_j(k_m - R_F) \tag{2-12}$$

where

k_j = required rate of return for the firm

R_F = interest rate on a risk-free bond

β_j = systematic risk of the firm

k_m = return on the market portfolio

For the division s, of firm j,

$$k_{js} = R_F + \hat{\beta}_{js}(k_m - R_F) \tag{2-13}$$

Combining Equations (2-12) and (2-13),

$$k_{js} = R_F + \frac{\hat{\beta}_{js}}{\beta_j}(k_j - R_F) \tag{2-14}$$

In Equation (2-14), $\hat{\beta}_{js}$ is not observable since the division is not traded in the capital market. However, if a stable relationship can be established between systematic risk, β_j, and accounting beta, β_{aj}, then this relationship can be used to estimate $\hat{\beta}_{js}$. Thus if

$$\hat{\beta}_j = \lambda_0 + \lambda_1(\hat{\beta}_{aj}) \tag{2-15}$$

then Equation (2-14) can be written and estimated as

$$\hat{k}_{js} = R_F + \frac{\lambda_0 + \lambda_1\hat{\beta}_{aj}}{\lambda_0 + \lambda_1\hat{\beta}_{ajs}}(k_j - R_F) \tag{2-16}$$

The Gordon-Halpern study thus consists of the following steps:

1. For a sample of firms, estimate the market betas and accounting betas. In this study the sample consisted of 32 industrials and 17 utilities. To estimate accounting betas, Gordon and Halpern used time series regression, not of accounting returns but of quarterly earnings growth. Their argument is that if earnings grow at a constant rate, under certain restrictive assumptions, dividends and prices will grow at the same constant rate, so that market returns will be related to earnings growth.
2. The relationship in Equation (2-15) is then established by a cross-sectional regression between market betas and accounting betas.
3. This relationship is used in Equation (2-16) along with estimates of the firm's and the division's accounting beta to calculate the divisional cost of capital.

The problem with this study is that accounting beta is used as the sole determinant of market risk. Even in the more elaborate and sophisticated empirical analysis of Beaver and Manegold, accounting beta explained only a small fraction of the variation in market betas. To the extent that this relationship is weak, the cost of capital estimate for the division must be suspect. What is needed is a more complete specification in which accounting beta is only one of the explanatory variables.

Hill and Stone (1980). Hill and Stone point out that most of the past work relating accounting risk to market risk did not deal explicitly with capital structure. Hamada (1972) and Rubinstein (1973) developed a theoretical relationship between equity risk (levered betas), operating risk (unlevered betas) and financial risk. The relationship is multiplicative. In the absence of taxes the Hamada-Rubinstein equation is

$$\beta^{m} = (1 + \frac{D}{S})\beta^{*} = \frac{\beta^{*}}{1 - F} \qquad (2\text{-}17)$$

where

β^{m} = levered beta, the overall equity risk

β^{*} = unlevered beta, the operating risk

D = market values of debt

S = market value of equity

$F = \frac{D}{V}$

V = market value of the firm = D + S

In the presence of taxes

$$\beta^{m} = (1 + \frac{(1 - T)D}{S})\beta^{*} = (\frac{1 - FT}{1 - F})\beta^{*} \qquad (2\text{-}18)$$

where

T = tax rate

Thus the Hamada-Rubinstein formulas decompose the overall equity risk into two multiplicative components--the intrinsic operating risk and financial risk. Debt financing magnifies the intrinsic operating risk as measured by β^{*}. It has a nonlinear multiplicative effect on intrinsic operating risk. Hill and Stone develop an accounting analogue of the Hamada-Rubinstein equation in which they relate accounting equity beta to the accounting measures of operating risk and capital structure.

Hill and Stone define the following:

ROA_i = return on assets for firm i

ROE_i = return on book equity for firm i

ROA_m = operating return on market index = $\sum_{i=1}^{N} W_i{*}ROA_i$

ROE_m = equity return on market index = $\sum_{i=1}^{N} W_i ROE_i$

$W_i, W_i{*}$ = weights of return in each index

N = number of stocks in the index

$\beta_i^0 = \frac{d(ROA)_i}{d(ROA)_m}$ = systematic operating risk or operating beta

$\beta_i^R = \frac{d(ROE)_i}{d(ROE)_m}$ = systematic equity risk

f = accounting equity ratio = common equity/total assets, a measure of financial risk

Then, under certain simplifying assumptions Hill and Stone derive a relationship between equity risk, β_i^R, operating risk, β_i^0, and financial risk f.

$$\beta_i^R = \frac{\beta_i^0/(1 - f_i)}{\sum_{j=1}^{N} w_j \beta_j^0/(1 - f_j)} \tag{2-19}$$

The key assumptions made in deriving this accounting analogue to the Hamada-Rubinstein equation are that average interest expense and debt ratio are unaffected by level of return on assets. Analogous assumptions are implicit in the Hamada-Rubinstein derivation--nonstochastic interest rate and the treatment of financial structure as a given parameter. Hill and Stone refer to β^R as the "risk-composed equity beta" since it is obtained from the two components of equity risk--operating risk and financial risk. They differentiate this risk-composed β^R from the standard covariance measure of equity beta,

$$\beta^C = \frac{\text{Cov}(\text{ROE}_i, \text{ROE}_m)}{\text{Var}(\text{ROE}_m)} \tag{2-20}$$

estimated from time series regression of ROE_i on ROE_m. The authors claim superior properties to the risk-composed β^R than to the covariance measure of equity beta β^C. They argue, correctly, that when β^C is estimated from a time series of past ROE_i values, there is an implicit assumption the equity return generating process is stable. Changes in financial structure or interest expense is a source of instability of β^C. Computing β^R from Equation (2-20) does not require stable financial structure since it is estimated from past return on assets (independent of capital structure) and current financial structure.

The rest of the study is empirical with the following main conclusions:

1. For the sample tested, market beta is more highly correlated with risk-composed equity beta, β^R, than with β^C obtained from time series regression of equity returns.
2. Period to period changes in market beta are related to changes in operating risk and financial structure. Forecasts of market beta could therefore be improved if one could predict future financial structure and operating risk.

Subrahmanyam and Thomadakis (1980). In an important study Subrahmanyam and Thomadakis (S-T) link capital market theory to the theory of the firm thereby providing a relationship between the systematic risk and firm variables, such as monopoly power and labor-capital ratio. This paper provides the most theoretically rigorous development, to date, of the relationship between market risk and its real determinants. S-T develop a single period model of the firm with stochastic demand and quantity setting behavior. The firm determines its output and quantity of labor, ex-ante. There is uncertainty regarding output price and wage rate at the end of the period. This results in uncertain cash flows and the relative volatility of this cash flow with that of a market index of all firms is a measure of the firm beta. Thus a relationship is established between firm beta and the firm variables. The specific development of the model is as follows:

1. The economy is composed of N firms each with an inverse demand function

$$\tilde{p}_j(q_j) = p_j(q_j)(1 + \tilde{e}) \qquad \text{for } j = 1,\ldots,N \qquad (2\text{-}21)$$

where

$\tilde{p}_j$ = random price of the firm's output

p_j = expected price

q_j = non-stochastic output

$\tilde{e}$ = noise term distributed $N(0,\sigma_e^2)$

2. The firm produces its output using two homogeneous inputs, labor and capital, and a production technique $f_j(k,L)$. The firm acquires capital, k_j, at the beginning of the period at unit price. Both

quantity, g_i, and labor required, L_j, are set ex-ante at the beginning of the period. However, payment is made at the end of the period, the wage rate being a random variable

$$\tilde{w} = w(1 + \tilde{v}) \qquad (2\text{-}22)$$

where

$\tilde{w}$ = random wage rate

w = expected wage rate

$\tilde{v}$ = noise term distributed $N(0,\sigma_v{}^2)$

Both $\tilde{e}$ and $\tilde{v}$, the uncertainty in prices and wage rates are economy wide, and not firm specific factors. It is also assumed that

$$\mathrm{Cov}(\tilde{e},\tilde{v}) = 0 \qquad (2\text{-}23)$$

that is, demand (price) uncertainty and wage rate uncertainty are uncorrelated.

3. Under these assumptions, the firm's cash flow is

$$\begin{aligned}\tilde{F}_j &= \text{Revenue} - \text{Costs}\\ &= p_j q_j(1 + \tilde{e}) - wL_j(1 + \tilde{v}) \qquad (2\text{-}24)\end{aligned}$$

4. In the CAPM framework the valuation formula for the cash flow $\tilde{F}_j$ is

$$V_j = [\bar{F}_j - h\mathrm{Cov}(\tilde{F}_j,\tilde{F}_m)]/(1 + i) \qquad (2\text{-}25)$$

where

V_j = market value of firm j

$\bar{F}_j$ = expected value of $\tilde{F}_j$

$\tilde{F}_m$ = aggregate cash flow of all firms

h = market price of risk

i = riskless rate of interest

5. From the assumed distributions of $\tilde{e}$ and $\tilde{v}$

$$\mathrm{Cov}(\tilde{F}_j,\tilde{F}_m) = \mathrm{Cov}(\tilde{F}_j \sum_i \tilde{F}_i)$$

$$= p_j q_j S\sigma_e^2 + wL_j D\sigma_v^2 \qquad (2\text{-}26)$$

where

$S = \sum_i p_i q_i$ = expected value of aggregate output

$D = w\sum_i L_i$ = expected value of aggregate labor

6. From the CAPM the firm's systematic risk

$$\beta_j = \frac{\mathrm{Cov}(\tilde{F}_j,\tilde{F}_m)V_m}{\mathrm{Var}(\tilde{F}_m)V_j} \qquad (2\text{-}27)$$

where

$V_m = \sum_i V_i$ = market value of all firms

$$\mathrm{Var}(\tilde{F}_m) = \mathrm{Var}(\sum \tilde{F}_i)$$

$$= S^2\sigma_e^2 + D^2\sigma_v^2 \qquad (2\text{-}28)$$

7. Substituting Equation (2-26) in Equation (2-27)

$$\beta_j = \frac{p_j q_j S\sigma_e^2 + wL_j D_j \sigma_v^2}{V_j} \; \frac{V_m}{\mathrm{Var}(\tilde{F}_m)} \qquad (2\text{-}29)$$

8. The rest of the paper evaluates Equation (2-29) under the assumptions, first of perfect competition and then of monopoly.

9. From Equations (2-22), (2-25) and (2-26), the market value of each firm is

$$V = [pq(1 - hS\sigma_e^2) - wL(1 + hD\sigma_v^2)]/(1 + i) \qquad (2\text{-}30)$$

Under competitive equilibrium

Certainty equivalent price = Certainty equivalent average cost

$$\mathrm{CEQ}[\tilde{p}] = \frac{\mathrm{CEQ}[\tilde{p}q]}{q} = p(1 - hS\sigma_e^2) \qquad (2\text{-}31)$$

$$CEQ[AC] = CEQ[\frac{\tilde{w}L + (1 + i)k}{q}]$$

$$= w(1 + hD\sigma_v^2)\frac{L}{q} + \frac{k(1 + i)}{q} \qquad (2\text{-}32)$$

Therefore

$$p(1 - hS\sigma_e^2) = w(1 + hD\sigma_v^2)\frac{L}{q} + \frac{k(1 + i)}{q} \qquad (2\text{-}33)$$

Substituting Equation (2-33) into the valuation equation (2-30)

$$V = k \qquad (2\text{-}34)$$

that is, under competitive equilibrium market value of the firm is equal to its asset costs. Also

$$V_m = k_m \qquad (2\text{-}35)$$

10. Finally with substitution of (2-33), (2-34) and (2-35) into the beta Equation (2-29) S-T derive

$$\beta_j = \frac{A + B(L_j/k_j)}{A + B(L_m/k_m)} \qquad (2\text{-}36)$$

where

$$A = [(1 + i)S\sigma_e^2]/(1 - hS\sigma_e^2)$$

$$B = wD\sigma_v^2 + [S\sigma_e^2(1 + hD\sigma_v^2)]/(1 - hS\sigma_e^2)$$

Neither A nor B is a firm specific variable.

11. In a cross-sectional analysis

$$\beta_j = a + b(L_j/K_j) \qquad (2\text{-}37)$$

12. For monopoly firms S-T assume that the firms act as price takers in all markets other than the output markets and that the firm's decisions have no impact on aggregate output and labor. The firms choose optimal output levels to maximize net present value of investment.

$$\text{MAX NPV} = V - Cq$$
$$= [q/(1 + i)][p(1 - hS\sigma_e^2) - wa(1 + hD\sigma_v^2) - c(1 + i)]$$

From the first order condition

$$\text{CEQ(marginal revenue)} = \text{CEQ(maringal cost)}$$

13. Using this relationship, with further simplification and rearrangement, the β_j of a monopoly firm is derived to be

$$\beta_j = \frac{(1 + i)S\sigma_e^2 + w(L_j/K_j)[S\sigma_e^2 x + (1 - U_j)zD\sigma_v^2]6z^{-1}}{(1 + i) + U_j y_j wX} \qquad (2\text{-}38)$$

where

$$X = 1 + hD\sigma_v^2$$
$$Z = 1 - hS\sigma_e^2$$
$$U_j = \frac{1}{\text{Price elasticity of demand}}$$

From their analysis and specifically from Equations (2-37) and (2-38), S-T draw the following major conclusions:

1. For competitive firms, the systematic risk is a linear function of the labor/capital ratio.
2. For monopolistic firms, the systematic risk is a nonlinear function of the labor/capital ratio and monopoly power. It is a direct function of labor/capital ratio and an inverse function of monopoly power.

The conclusion that systematic risk is a positive function of the factor proportions appears to be counterintuitive. The labor/capital ratio could be considered to be a proxy for variable/fixed cost ratio or the reciprocal of operating leverage. The S-T conclusion then implies that the lower the operating leverage the higher the systematic risk, contrary to traditional belief that associates high risk with high operating leverage. In the traditional model it is assumed that output is random but prices and average variable costs are fixed. The firm's risk for a given operating margin is then determined by uncertainty in the output. As operating leverage and hence operating margin increases so does the firm's risk. S-T criticize this analysis since it does not relate optimal choice of factor proportions and price to uncertainty in output. They argue that the operating margin itself is a function of demand uncertainty since firms can change their factor proportions in response to unstable demand. Their own model which simultaneously considers uncertainty in input and output markets is more realistic. Their second result that beta is inversely related to monopoly power is consistent with traditional beliefs and also supported by the empirical study of Sullivan (1978) discussed earlier.

With regard to their analysis itself there are two criticisms pointed out by Chiang and Goldenberg (1980).

1. The S-T assumption that uncertainty in price and wage rates is unrelated (i.e., $\mathrm{Cov}(\tilde{e},\tilde{v}) = 0$) may not be valid.
2. In the S-T model the aggregate cash flow, $\tilde{F}_m$, is the sum of the cash flows of all firms in the economy.

$$\tilde{F}_m = \sum_j F_j = \sum_j [p_j q_j (1 + \tilde{e}) - wL_j (1 + \tilde{v})] \qquad (2\text{-}39)$$

In the CAPM framework $\tilde{F}_m$ should be the aggregate cash flow of all risky assets, including human capital and not just the aggregate cash flows of all firms.

$$\tilde{F}_m = \sum_j[p_jq_j(1 + \tilde{e}) - wL_j(1 + \tilde{v})] + \sum_j wL_j(1 + \tilde{v})$$
$$= \Sigma p_jq_j(1 + \tilde{e}) \qquad (2\text{-}40)$$

Chiang and Goldenberg (1980). The authors re-work the S-T model after correcting for the two criticisms discussed above. They assume

1. $\mathrm{Cov}(\tilde{e},\tilde{v}) \neq 0$.
2. Human capital is a risky asset so that the value of wages should be added to the firm cash flows to obtain aggregate cash flows for the market.

With these corrections Chiang and Goldenberg (C-G) derive

$$\beta_j = 1 + \frac{w}{1 + i}\,\frac{L_j}{k_j}\,\frac{\sigma_e^2 - \sigma_{ev}^2}{\sigma_e^2} \qquad (2\text{-}41)$$

for competitive firms. The relationship between β_j and the factor proportions is still linear but the direction depends on the sign of $\sigma_e^2 - \sigma_{ev}^2$. If $\sigma_e^2 - \sigma_{ev}^2 > 0$, β_j is a positive function of L_j/k_j as in the S-T analysis. If $\sigma_e^2 - \sigma_{ev}^2 < 0$, β_j is inversely related to factor proportions and therefore positively related to operating leverage, consistent with the traditional analysis. These results are more general than those obtained by S-T. However, if it is assumed that human capital though a risky asset is non-tradeable, then the C-G results will be equivalent to the S-T results.

For monopoly firms C-G derive

$$\beta_j = 1 + \frac{(1 - U_j)w\frac{L_j}{k_j}(\sigma_e^2 - \sigma_{ev}^2)}{\sigma_e^2[(1 + i) + XU_j w\frac{L_j}{k_j}]} \qquad (2\text{-}42)$$

where

$X = 1 - hs\sigma_{ev}^2$

$s = \Sigma p_i q_i$

As in the S-T analysis β_j is a non-linear function of factor proportions and monopoly power, but the sign of the relationship depends upon the sign of $\sigma_e^2 - \sigma_{ev}^2$.

The study by Subrahmanyam and Thomadikis and its extension by Chiang and Goldenberg is the first rigorously developed theoretical relationship between systematic risk and firm variables. These models are therefore eminently suitable for estimating risk/return of non-traded firms. It should be possible to estimate the non-linear relationship between systematic risk, factor proportions and market power. This relationship can then be used to estimate the market risk of subsidiary firms. However the accuracy of the estimate will depend critically on the accuracy with which factor proportions and market power can be measured. As we shall see later the measurement problems associated with this approach are extremely severe.

Myers and Turnbull (1977). The authors use a multiperiod intertemporal CAPM approach to arrive at the real determinants of a firm's systematic risk. They develop a valuation formula for an uncertain income stream under the assumption that the CAPM holds in each period. From this valuation equation a relationship between the firm and its real determinants is derived.

The firm or asset generates uncertain stream of cash flows,

$$\tilde{x}_1, \tilde{x}_2, \ldots, \tilde{x}_t \text{ to some point } t = T$$

The problem is to find the present value, P_0, of the cash stream. Since the CAPM holds in each period,

$$P_t = \frac{E(\tilde{x}_{t+1} + \tilde{P}_{t+1}/\phi_t) - \lambda \operatorname{cov}(\tilde{x}_{t+1} + \tilde{P}_{t+1}, \tilde{R}_{m,t+1})}{1 + r}, \qquad (2\text{-}43)$$

where

$E(\tilde{x}_{t+1}/\phi_t)$ = Investors' expectation of x_{t+1} based on information set ϕ_t.

$E(\tilde{P}_{t+1}/\phi_t)$ = Investors' expectation of $\tilde{P}_{t+1}$ based on ϕ_t.

$R_{m,t+1}$ = Return on market portfolio.

λ = Market price of risk, assumed constant over time.

r = Risk-free rate, assumed constant over time.

Equation (2-43) points out the problem with the CAPM: today's price cannot be determined without knowing the probability distribution of tomorrow's price. To solve this problem, it is necessary to specify how investor expectations are formed.

Assume that investors forecast future cash flows from current information, with actual and expected cash flows related by

$$\tilde{X}_t = E(\tilde{x}_t/\phi_{t-1})(1 + \tilde{\delta}_t), \qquad (2\text{-}44)$$

where $\tilde{\delta}_t$ is a random disturbance term. The realized value of the disturbance term will depend upon unanticipated events specific to the firm (μ_t) and upon unanticipated changes external to the firm (I_t).

$$\tilde{\delta}_t = b\tilde{I}_t + \tilde{\mu}_t, \qquad (2\text{-}45)$$

where

$\tilde{I}_t$ = Unanticipated changes (forecasting error) in some general economic index.

b = Firm-specific factor representing the sensitivity of the disturbance term to I_t.

μ_t = Unanticipated firm-specific disturbance term.

Under the further assumptions of no systematic growth (to be relaxed later) and a simple adaptive expectations model for forecasting cash flows, the valuation equation for the income stream can be determined.

$$E(\tilde{x}_{t+1}/\phi_t) = E(\tilde{x}_t/\phi_{t-1})(1 + \eta\delta_t), \tag{2-46}$$

where η = Elasticity of expectations for $0 < \eta < 1$. Since the cash flow stops at $t = T$, $P_T = 0$. Therefore,

$$P_{T-1} = \frac{E(\tilde{x}_t/\phi_{T-1})(1 - \lambda b\sigma_{Im})}{1 + r}, \tag{2-47}$$

where

$\sigma_{Im} = \text{cov}(I_t, R_{mT})$.

Knowing the expression for P_{T-1}, P_{T-2} and so on can be derived, working backward until an expression is obtained for P_0.

For long-lived assets or for an on-going firm, $T \to \infty$ and the expression for P_0 simplify to the following:

$$P_0 = \frac{E(\tilde{x}_1/\phi_0)(1 - \lambda b\sigma_{Im})}{r + \lambda\eta b\sigma_{Im}}. \tag{2-48}$$

If the cash flows are assumed to grow at a rate g,

$$P_0 = \frac{E(\tilde{x}_1/\phi_0)(1 - \lambda b\sigma_{Im})}{r - g + \lambda\eta b\sigma_{Im}(1 + g)}. \tag{2-49}$$

In the absence of uncertainty ($\lambda = 0$), Equation (2-49) reduces to the Gordon constant growth equation.

From the valuation equations, a one-period rate of return for the firm/asset can be derived, and hence an expression for systematic risk, β:

$$\beta = \frac{[(r + \eta)/(1 - \lambda b\sigma_{Im})](b\sigma_{Im})}{\sigma_m^2}. \tag{2-50}$$

In the presence of growth,

$$\beta = \frac{\frac{r - g + \eta(1 + g)}{1 - \lambda b\sigma_{Im}}(b\sigma_{Im})}{\sigma_m^2} \tag{2-51}$$

Equations (2-50) and (2-51) specify the determinants of systematic risk. From these relationships Myers and Turnbull conclude that for long-lived assets ($T \to \infty$) or on-going firms the firm beta is a function of

1. Growth in cash flows.
2. Forecast errors in cash flows and in market returns.
3. Cyclicality in cash flows.
4. Procedure by which investors forecast cash flows, measured by the elasticity of expectations.

If these variables could be measured using historical data Equation (2-51) can be estimated for traded firms and used to predict beta of subsidiary firms. However, one would encounter severe problems in measuring the variables and would have to make the unrealistic assumption that the variables are stable over time. Thus the Myers-Turnbull study provides considerable insights into the real determinants of beta in an intertemporal CAPM framework but is unlikely to be successful operationally.

Summary

From the review of the literature the main points that emerge, relevant to the rest of this study, are as follows:

1. Accounting betas are statistically significant determinants of market betas. This conclusion is supported strongly by the studies of Beaver and Manegold (1975) and Hill and Stone (1980). However, accounting betas explain only a small portion of the variance in market betas.
2. Other real determinants of market risk and cost of capital are monopoly power and the labor-capital ratio. Subrahmanyam and Thomadakis (1980) and Chiang and Goldenberg (1980) have developed theoretical relationships between market risk and these variables. Sullivan (1978) demonstrated empirically the relationship between market risk and monopoly power.
3. The validity of the estimates of subsidiary capital costs can be tested under the assumption of value additivity. However, for the test to be meaningful we need models that provide estimates of both the cost and the market value of the equity of subsidiaries. This is because the validity test compares the "observed" cost of equity

of the parent with the sum of the weighted average estimates of equity costs of the subsidiary, the weights being the equity market value fractions. Fuller and Kerr (1981) could only estimate the market beta of the non-traded firms but not their market values. Their validity test is therefore flawed since they had to use proxy measures--fraction of total sales--for market weights.

In the next chapter we develop alternative methodologies/models to estimate the capital costs of subsidiaries and test the validity of the estimates.

CHAPTER III
THEORETICAL AND EMPIRICAL FRAMEWORK

Introduction

Within the framework of the Subsidiary Approach we have developed alternative methodologies and model specifications to estimate the subsidiary cost of capital. We will apply all of these methodologies to estimate capital costs of the electric utility subsidiaries. We will then critically evaluate the model estimations, their properties and performance, and only those found "acceptable" will be used to estimate the capital costs of the telephone subsidiaries and Western Electric Company--a non-regulated subsidiary of a regulated parent, AT&T.

The Subsidiary Approach analyzes each subsidiary as an independent entity with unique risk characteristics which determine its cost of capital. Within this framework we have developed methodologies based on the analogy approach and the analytical approach. In the analogy or pure play approach we identify a group of companies whose stock is traded in the capital markets and whose risks are comparable to those of the subsidiary being analyzed. We then assign to the subsidiary, a cost of capital equal to the average cost of capital for the comparable risk group. To estimate the cost of capital of the risk group we use the conventional market models, like the DCF model and the CAPM. The accuracy of the estimates of subsidiary capital costs would depend on the appropriateness of the risk group chosen and the accuracy with which the capital costs of this risk group are estimated. In the analytical approach we estimate functional relationships between risk/return and their real or fundamental determinants. The measurement of these fundamental variables does not depend on capital market data so that we could directly use the relationship to estimate the subsidiary cost of capital.

Within the analytical approach we have developed four separate econometric models. The first is a purely empirical model in which we estimate an econometric relationship between the cost of equity of a sample of comparable-risk traded firms and the fundamental variables discussed in the literature survey. All the risk variables that might be determinants of equity costs are included as explanatory variables, but there is no particular theoretical basis to the specified functional relationship. As in the pure play approach, this model also depends on the accuracy with which the equity costs of the traded firms--the dependent variable--are estimated using the cost of capital models. The second model is based on the Gordon equity valuation equation. The third model is based on a variation of the CAPM, developed by Litzenberger and Rao (1971). Finally we developed a model based on the theory of the firm which relates systematic risk to the microeconomic variables of the firm--specifically, factor proportions and monopoly power. As we have noted above two of the methodologies depend upon the estimation of equity costs of the comparable risk groups. We, therefore, begin the chapter with a discussion of the use of the cost of capital models to estimate equity costs of traded firms. Based on this overview, we will subdivide the chapter into the following sections:

1. The estimation of equity costs of traded companies.
2. The analogy or pure play methodology.
3. The analytical approach consisting of the following:
    a. Econometric model based on the real determinants of equity costs.
    b. Econometric model based on the Gordon valuation equation.
    c. Econometric model based on the CAPM.
    d. Econometric model based on the theory of the firm.

The Estimation of Equity Costs of Traded Firms

The two most widely recognized cost of capital models are the Discounted Cash Flow (DCF) model and the Capital Asset Pricing Model (CAPM). The CAPM is theoretically more rigorous but also has more severe implementation problems. The DCF model is more widely used, especially in regulatory rate-hearing proceedings in which the estimation of equity costs constitutes the more important and controversial element. In the DCF model the value or price (P_0) of a stock is the present value of a future, uncertain dividend stream (D_t) discounted at the investors' expected/required rate of return, k_s. The CAPM is based on explicit consideration of equilibrium in the capital market and provides a functional relationship between risk and return. The expected/required rate of return is a linear function of the systematic or relevant risk, measured as the relative volatility of the stock returns with respect to returns on the market portfolio. The systematic risk determines the risk premium demanded by investors for bearing the relevant risk. A third approach is the Risk Premium Approach in which the cost of equity is the sum of the prevailing risk-free rate and a stable risk premium commensurate with the riskiness of the stock. This approach is thus similar to the CAPM in concept, the difference being in the way the risk premiums are estimated. All of these models have varying degrees of implementation problems associated mainly with the measurement of the model variables. We will now discuss the application of each of these models.

The Discounted Cash Flow (DCF) Model

In this model the stock price is the present value of a stream of uncertain future dividend payments

$$P_0 = \sum_{t=1}^{\infty} \frac{D_t}{(1 + k_s)^t} \tag{3-1}$$

Under the assumption that dividends will grow indefinitely at a constant rate, g, Equation (3-1) simplifies to the Gordon constant growth DCF equation

$$P_0 = \frac{D_1}{k_s - g} = \frac{D_0(1 + g)}{k_s - g} \tag{3-2}$$

or

$$k_s = \frac{D_1}{P_0} + g \tag{3-3}$$

$$= \begin{matrix}\text{dividend}\\ \text{yield}\end{matrix} + \begin{matrix}\text{growth rate}\\ \text{in dividends}\end{matrix}$$

In this equation

D_1 = expected dividend per share in the next period = $D_0(1 + g)$

D_0 = current dividends per share

g = constant growth rate in dividends

P_0 = current stock price

k_s = investors' expected rate of return

The rate of return, k_s, that the investor expects to earn when he buys the stock at P_0 is the sum of the expected dividend yield and the expected constant growth rate in dividends. For the stock price to be in equilibrium the investor's expected rate of return must also be equal to his required rate of return. Thus, k_s is an estimate of the cost of equity.

Another form of the DCF model is the non-constant growth model in which we assume that dividends grow at a non-constant rate for a certain number of (transitional) years after which the growth rate is constant. In this model we estimate the expected/required rate as the solution value of k_s in the equation

$$\begin{aligned} P_0 &= \sum_{t=1}^{N} \frac{D_t}{(1 + k_s)^t} + \frac{P_N}{(1 + k_s)^N} \\ &= \sum_{t=1}^{N} \frac{D_t}{(1 + k_s)^t} + \frac{D_N(1 + g_N)}{k_s - g_N}\left(\frac{1}{1 + k_s}\right)^N \qquad (3\text{-}4) \end{aligned}$$

In Equation (3-4)

N = number of years of non-constant growth

g_N = constant growth prevailing after year N

D_N = dividend paid in year N.

This model is particularly applicable to growth firms for which there may be a period during which earnings and dividends grow at "supernormal" rates after which constant normal growth rates prevail. The model is also suited for firms that have temporarily depressed earnings. As the firms come out of the depressed state, the growth rate in earnings and dividends will be higher in the transitional period than in the stable normal period that follows. The utilities during the late 1970s and early 1980s were in this situation.

In both the constant and non-constant growth versions of the DCF model, there are problems and disagreements on how the model variables should be measured. In regulatory proceedings analysts and "expert witnesses" use a wide range of measurement techniques. With respect to measurement of dividend yields (D_1/P_0), analysts often use a historical average of stock prices over periods ranging from 1 month to 1 year or more. They argue that the current spot price may not be an equilibrium price. This argument is without merit and goes against the efficient market hypothesis according to which the spot price reflects all available information including past prices. Also the very use of the DCF model to estimate the required rate of return is based on the assumption that stock prices are always at equilibrium so that the expected and required rates are equal. The use of historical prices will cause a downward bias in the dividend-yield estimate when stock prices have a downward trend and vice versa. With respect to expected dividends, some analysts consider the current dividend, D_0, to be the appropriate measure. They would be correct if dividends were continuously compounded, but given that dividends are paid periodically, the expected dividend should be measured as the next period dividend, D_1. There would be downward bias if current dividends were used to estimate the expected dividend yields. In this study we will measure dividend yield, as defined, as the ratio of the dividend expected next year, D_1, to the current spot price, P_0. The measurement error in D_1 or P_0 is not likely to be severe.

Measurement problems can be serious in the estimation of the dividend growth rate. Analysts use a number of alternative techniques to measure the growth rate.

Use of Historical Growth Rate Measures. A most commonly used technique is the use of historical growth rates in dividends per share (DPS), earnings per share (EPS) and book value per share (BVS) as proxies for future dividend growth rate. The historical growth rates are measured, alternatively, as the compound growth rate from the base year to the terminal year of the estimation horizon, or as the continuously compounded growth rate. In the former approach only the beginning and ending values of DPS, EPS or BVS are used to estimate g. Thus,

$$DPS_N = DPS_0(1 + g)^N \tag{3-5}$$

$$g = \left(\frac{DPS_N}{DPS_0}\right)^{1/N} - 1.0$$

where N = number of years over which g is estimated. In this method the estimate of g will obviously be very sensitive to the beginning and ending periods chosen. In the continuous compounding method we have the following:

$$DPS_t = DPS_0(e)^{-gt} \tag{3-6}$$

or

$$\ln DPS_t = \ln DPS_0 - gt \tag{3-7}$$

The growth rate g in Equation (3-7) is estimated as the slope of the log-linear regression of DPS_t against time, t. This approach uses all the DPS values over the estimation horizon and is therefore less sensitive to the choice of beginning and ending periods. Regardless of how the historical growth rates are measured, the basic problem with this technique is the assumption that ex-post measures are adequate proxies of ex-ante measures. There is no reason to believe that history will repeat itself and that growth rates realized in the past will continue to be realized in the future. Basically, historical measures use only a subset of all the information that can be used to project future rates. They use only historical data about the past performance of the firm without any consideration for the current and future prospects of the firm or the economy. For an estimation period chosen the historical growth rate in dividends and earnings could easily be negative. It makes little sense to assume that the firm's long-term expected growth rate, g, used in the DCF equations, will also be negative. Cost of equity measures using historical growth rates are often lower than the yield on risk-free government securities.

The historical BVS growth rate has an additional problem in that a bias is introduced if the return on book equity (ROE) is not constant. As an identity

$$\mathrm{BVS} = \frac{\mathrm{EPS}}{\mathrm{ROE}} \tag{3-8}$$

Therefore

$$\ln \mathrm{BVS} = \ln \mathrm{EPS} - \ln \mathrm{ROE}$$

Taking derivatives

$$d \ln \mathrm{BVS} = d \ln \mathrm{EPS} - d \ln \mathrm{ROE}$$

$$\frac{d\ \mathrm{BVS}}{\mathrm{BVS}} = \frac{d\ \mathrm{EPS}}{\mathrm{EPS}} - \frac{d\ \mathrm{ROE}}{\mathrm{ROE}}$$

or

$$\text{BVS growth} = \text{EPS growth} - \text{ROE growth} \tag{3-9}$$

In the DCF model we need a measure of DPS growth rate which under the assumption of a constant payout rate is equal to the EPS growth rate. From Equation (3-9) we see that if BVS growth is used as a proxy for EPS growth, it will be a downward biased estimate if ROE growth is positive. Thus, during times of increasing capital costs, when the utility's allowed and earned ROEs are increasing, as during most of the late 1970s, BVS growth underestimates the required DPS growth. The reverse is true when capital costs are falling. Thus none of the historic growth measures are appropriate for use in the DCF model and we will not use any such measure in our study.

Use of Retention Growth Rate. An alternative measure often used is the retention growth rate. The rationale for using this measure is that the firm's earnings and dividends grow through reinvested earnings and the return earned on it. If the retention rate and return on book equity (ROE) are constant, then the retention growth rate in dividends will also be constant. The retention growth rate will be an exact measure of the expected growth, used in the DCF equation, if the firm does not engage in stock financing. If the firm finances its investment with external equity, in addition to retained earnings, the expected growth in earnings and dividends will be

$$g = \text{retention growth} + \text{stock financing growth} \tag{3-10}$$

The stock financing growth component will be positive if the firm issues new stock at a price greater than its book-value per share, that is, if the firm has a P/B ratio greater than 1.0. It will be negative if P/B is less than 1.0 and zero if P/B is equal to 1.0. The price-book ratio of a firm will be equal to 1.0 if it earns a rate of return of book equity equal to the equity cost. Since utilities are regulated to earn a "fair" rate of return equal to the cost of capital, it is reasonable to assume that over the long run the P/B ratio will be 1.0, in which case the stock financing growth rate component can be ignored. The constant dividend growth rate will then be equal to the retention growth rate which is measured as

$$g = b(ROE) \tag{3-11}$$

where

b = expected retention rate
= 1 - expected payout rate (POR)

ROE = expected rate of return on equity

Since both b and ROE are ex-ante measures there is again the question of how best to measure these variables. Historical measures--both simple and weighted average values of past data--have problems that we have already enumerated. These problems are more severe in the measurement of expected ROE than in the measurement of expected payout or retention rate. Firms have target payout ratios which they try to achieve. If it can reasonably be assumed that the actual payout rates fluctuate about this target value, then an average of past payout rates would be an unbiased approximation of this target or expected payout rate. With respect to ROE, it is more reasonable to measure it as a normalized value rather than as a historical average or the current value. Thus

$$\text{Normalized ROE} = \text{NROE} = \frac{\text{Expected EPS}}{\text{Expected BVS}}$$

$$\text{Expected EPS} = \frac{\text{Expected DPS}}{\text{Expected POR}}$$

Therefore

$$\text{NROE} = \frac{\text{Expected DPS}}{(\text{Expected POR})(\text{Expected BVS})}$$

$$= \frac{\text{DPS}_0(1 + g)}{(\text{POR})(\text{BVS}_0)(1 + g)}$$

Under conditions of constant payout rate and ROE, the growth in dividends, earnings and book value will be equal. Therefore

$$\text{NROE} = \frac{\text{DPS}_0}{(\text{POR})(\text{BVS}_0)} \tag{3-12}$$

$$= \frac{\text{Current book yield of dividends}}{\text{Expected payout rate}}$$

The expected payout rate is measured as the average of past payout rates as discussed above. Thus the retention growth rate which we use in the DCF equation is best measured as

$$g = b(NROE)$$

or

$$g = (1 - POR)(\frac{DPS_0}{(POR)(BVS_0)}) \qquad (3\text{-}13)$$

This is one of the measures of g that we use in this study to estimate the DCF cost of equity.

Use of Analysts' Forecasts. Growth rates projected by the analysts of various investment services are based upon a larger information set than forecasts based solely on historical data. Analysts base their forecasts, not only on the basis of past and current data, but also on future estimates of the prospects of the firm and the economy. They attempt to estimate ex-ante measures of growth rates. The problem with using an analyst's forecast is that it may not represent the consensus opinion of the market. If the analyst is more optimistic about the growth prospects of the firm than is the market, the expected rate of return estimated by the DCF model using this forecast will be higher than the marginal rate of return required by the market. The DCF model would overestimate the cost of equity. The reverse would be true if the analyst was more pessimistic about the firm's future than the rest of the market. If data are available, an average value of the forecasts of several analysts would be more representative of the consensus market estimate of g. For the estimation horizon in this study, 1977-1981, the only long-term forecasts available are by Value Line Investment Services. More recently forecasts for utilities are also being provided by Merrill Lynch and Salomon Brothers. In this study we will estimate the DCF cost of equity for traded firms using the following:

1. The non-constant growth model with Value Line forecasts of the transitional and the constant growth in dividends.
2. The constant growth model with dividend yield measured as D_1/P_0 and expected growth measured as g = average retention rate x normalized rate of return on equity as developed in Equation (3-13).

The Capital Asset Pricing Model (CAPM)

In the CAPM, expected rate of return is given by the following:

$$E(R)_i = R_F + \beta_i[E(R)_m - R_F] \qquad (3\text{-}14)$$

where

$E(R)_i$ = expected rate of return on stock i

R_F = risk-free rate

β_i = systematic, non-diversifiable risk of stock i

$E(R_m)$ = expected rate of return on the market portfolio of all assets

Thus, according to this model, the expected/required rate of return, $E(R)_i$, or the cost of equity, is the sum of the risk-free rate and the market premium, $[E(R_m) - R_F]$, adjusted for the risk of the stock, β_i, relative to the risk on the market portfolio. The model provides an explicit relationship between ex-ante risk and return under conditions of equilibrium in the capital market. As a theoretical, ex-ante model, it is more rigorous in its development than the DCF model. It is also potentially testable, but there are problems in the testing and the implementation of the model. Most of the empirical studies on the CAPM, reviewed by Jensen (1972), are concerned with testing cross sectionally the linearity between risk and return. In these studies returns on stocks, R_i, are measured as the average of the historical holding period returns. The beta coefficients, β_i, are measured using the "market model" which describes the return generating process

$$R_i = \alpha_0 + \beta_i R_m + e_i \tag{3-15}$$

β_i is estimated as the slope coefficient of the time series regression between holding period returns on stock i and the holding period return on the market portfolio, typically the New York Stock Exchange index of stocks. Finally, in a cross-sectional analysis, stock returns, R_i, are regressed against their beta coefficients, β_i, to test Equation (3-14). The estimated intercept is compared with R_F and the estimated slope with the market premium $(R_m - R_F)$. This is the simplest form of the test of the basic version of the CAPM. Later tests were considerably more sophisticated in terms of the econometric techniques used, but all were essentially tests of linearity of the CAPM equation. These tests did establish linearity although the intercepts and slopes were different from the hypothesized values. Roll (1977), in a study of great significance, showed that these tests of linearity did not provide the validity of the CAPM. He argued that the only valid test of the CAPM is the test that the market portfolio is mean-variance efficient. The linearity follows, mathematically, from the mean-variance efficiency of the index chosen as the market portfolio. It is possible to choose any index that is ex-post efficient and show exact linearity between R_i and β_i. Thus, linearity, per se, does not validate the CAPM. Only if the index chosen is the market portfolio of all assets, as stipulated in the CAPM, will the linearity test be appropriate. Since identification of such a portfolio of all conceivable assets is almost impossible, the empirical tests of the CAPM will always be questionable. Even if we were to assume that the model is valid, ex ante, there are severe problems in its use to estimate the cost of equity capital.

With respect to the measurement of the risk-free rate, R_F, the choice is between estimating R_F as the interest rate on short-term Government Treasury-bills or on long-term Government bonds, both free of default risk. The advantage of using Treasury bills as the risk-free security is that it is free of interest rate or maturity risk. However, the interest rates on T-bills are extremely sensitive to the actions of the Federal Reserve System trying to control the money supply. Short-term rates therefore tend to be volatile. The advantage of choosing long-term Government bonds as the risk-free security is that the interest rates are more stable and less affected by the action of the Fed. However, long-term bonds are subject to interest rate risk. Thus the choice is not unambiguously clear. From a practical standpoint it makes more sense to measure R_F as the more stable interest rate on long-term bonds. In regulatory proceedings, the use of short-term rates to measure equity costs would necessitate very frequent updating of the equity costs and rates as the short-term rates fluctuated over time. In this study we will use the yield on a 20-year constant maturity Government bond as a measure of the risk-free rate.

Measurement of the beta coefficient presents more serious problems. Typically the beta coefficient is measured as the slope coefficient of the time-series regression described by Equation (3-15). The stock returns, R_i, are measured as monthly holding-period returns and the market returns as the monthly holding period returns on a market index, typically the NYSE index. The estimation horizon is 5 years, providing 60 observations for the regression. The problem with this estimation technique is that it assumes the beta coefficient is stationery over time. It proxies historical betas for ex-ante betas. It uses only past return series to predict future risk which is likely to be a function of the current and future prospects of the firm and the economy. Also, Lerner and Breen (1972) have shown that the estimated beta coefficient, hence cost of equity, is quite sensitive to the choice of the market index, the holding periods over which returns are measured and the overall estimation period. Since there are no objective criteria for choosing any of these parameters, the estimated capital costs tend to be subjective and variable from one analyst to another.

Finally, there is the question of measuring the market risk premium, $[E(R_m) - R_F]$. The most widely used measure of the market risk premium is the historic measure provided by Ibbotson and Sinquefield (1982). In this measure the market premium is the difference between the geometric means of holding period returns on the portfolio of NYSE stocks and a portfolio of Government bonds or T-bills. The mean values are calculated over a long time horizon. For example, the premium for

1981 could be measured as the difference between the geometric means estimated over the period 1926-1981. It is argued that under the "fair-game" model assumption the average realized rate will approximate the expected rate over a long period of time. However, the data on the returns show that the market risk premium is quite sensitive to the averaging period and to the choice of the beginning and ending periods. This again adds an element of subjectivity to the estimation of the market premium and hence of the equity costs.

For all these reasons, the estimation of equity costs using the CAPM is likely to be unreliable. In regulatory proceedings, the CAPM approach is rarely admitted. To the extent that cost of equity estimates of the traded, comparable-risk firms are subject to error, subsidiary capital costs using the pure play approach will also be unreliable. However, for the sake of completeness we will estimate the parent and subsidiary capital costs using the CAPM. We will measure R_F as the yield on a 20-year Government bond; beta coefficients as historical betas and for market risk premiums we will use the Ibbotson-Sinquefield historical measure and a measure of expected market risk premiums discussed in the following section.

The Risk Premium Approach to Estimating Equity Costs

In this approach the market-determined required rate of return on a share of common stock is given by

$$\begin{aligned} R_i &= \text{risk-free rate} + \text{risk premium} \\ &= R_F + [RP]_i \qquad (3\text{-}16) \end{aligned}$$

Thus, the cost of equity at any point in time is calculated by adding the appropriate risk premium to the prevailing risk-free rate. This approach is therefore similar to the CAPM approach; the differing being in the method of calculating the risk premium. In the CAPM approach

$$[RP]_i = \beta_i[E(R_m) - R_F] \qquad (3\text{-}17)$$

The risk premium here is the market risk premium adjusted for the firm specific risk β_i. Conceptually this is an appropriate measure of the required premium for the firm. However, as discussed in the previous section in the implementation of the CAPM, historical measures of beta and market risk premiums are used which makes the estimate of the firm risk premium unreliable. In the risk premium approach as developed by Brigham and Shome (1982):

1. Historical measures of beta are rejected in favor of fundamental risk factors that consider the current and future risk of the firm.
2. Historical measures of risk premiums are rejected in favor of ex-ante or expected premiums.

For example, the bond rating of a company could be used as a measure of its risk. Bond rating agencies do consider present and expected future performance of firms in addition to historical performance. The bond rating is therefore more representative of ex-ante risk than is historical beta. The downgrading of AT&T's bonds because of higher risks in its future competitive operations would not be reflected in its historical beta which continues to be low. If bond rating is used as the measure of the firm's risk, the risk premium approach would estimate equity costs of a utility as follows:

1. Divide the utility industry into risk groups based on bond rating.
2. For each risk group estimate the ex-ante risk premium at several points in time--monthly or annually.
3. If the risk premiums are reasonably stable or fluctuate about a central mean, then the average value of the premiums is a measure of the premium appropriate for the risk group.
4. To measure the equity cost of the risk group at any point in time, the prevailing bond yield is added to the estimated average premium.

The estimation of the expected risk premium consists of the following steps:

1. The expected premium for the risk group, G, is defined as:

$$[RP]_G = \text{expected rate of return on G - risk-free rate}$$
$$= E(R)_G - R_F$$

2. The expected rate of return for the risk group is the average of the DCF rates of return on the individual firms in the group. The individual DCF returns are estimated using the constant growth model with normalized growth measures and/or the non-constant growth model with Value Line forecasts used to measure the transitional and normal growth rates.
3. When the index chosen is a broad-based market index the estimated premium is the market risk premium which can be used in the CAPM

approach instead of the Ibbotson and Sinquefield historical premiums. Brigham and Shome (1982) report expected market risk premiums using the Dow Jones Industrials as the market index.

In the risk premium approach described, with bond rating as the risk measure, equity costs, obviously, can only be measured for the rating groups as a whole. All utilities in a particular rating group will have the same equity cost. This approach is particularly amenable to the pure play approach in which the subsidiary cost is the average cost of a comparable risk group.

To summarize this section:

1. Estimates of equity costs of the traded firms are needed both in the pure play approach and in the econometric approach that relates equity costs to its fundamental determinants.
2. We will estimate equity costs using the DCF, the CAPM and the risk premium approaches.
3. In the DCF approach we will use the constant growth model with normalized retention growth measures and the non-constant growth model with Value Line growth forecasts.
4. In the CAPM approach we will measure the risk-free rate as the yield on a 20-year Government bond and beta coefficients as historical betas from the estimation of the market model. For the market risk premium we will use both the historical Ibbotson-Sinquefield measure and the ex-ante measure reported by Brigham and Shome.
5. In the risk premium approach we will measure equity costs for the various bond rating groups by adding the bond yield to the estimated expected premiums for these groups.

The Pure Play or Analogy Methodology

The first step in the pure play approach is to choose a group of traded firms whose risk is comparable to the risk of the subsidiary whose capital cost is being measured. The second step is to measure the average cost of capital for the comparable risk group using the cost of capital models. The estimate of the subsidiary cost of capital is the average cost of the risk group. If industry classification is used as the criterion for choosing the risk group then the total sample of the electric utility firms would constitute the risk group. The problem with such a broad criterion is that the methodology will not differentiate between subsidiaries of different risks in the industry. All subsidiaries would have the same estimate of capital cost. At the other extreme we could match the subsidiary to the comparable-risk group on the basis of a series of risk criteria like size, leverage, accounting treatment of construction work in progress and depreciation, coverage ratio, etc. A single measure that captures most of these risk measures is the bond rating.

Rating agencies do examine a firm's debt ratio, coverage ratio, regulatory risks, etc. Therefore in the analogy approach we choose bond rating as the main criterion for selecting the comparable risk groups.

1. For the analysis of subsidiaries of utilities we use bond rating as the sole criterion.
2. For Western Electric which is an unregulated subsidiary of a regulated parent we use three screens, in series, to arrive at the comparable risk group. The first criterion is the nature of the

> firm's business. Since Western Electric is a manufacturing company, the comparable group should consist of manufacturing companies whose stock is traded in the capital market. The second criterion is size. Since Western Electric is a large manufacturing company with sales in the top 20 of the Fortune 500 group of companies, the comparable group was chosen from the top 50 manufacturing companies in the Fortune 500 group. The final criterion applied is bond rating. Western Electric's bonds are rated high (AAA) so the comparable group finally selected were firms from the Fortune 50 group that had high-rated bonds (AA or AAA). Twenty-five firms (Fortune 26) satisfied the requirements of being large manufacturing firms with high-rated bonds. We also looked at other criteria such as financial strength, as reported by Value Line, and the Standard & Poor's stock ranking. These criteria are highly correlated with bond rating and do not cause changes in the final risk group selected in the Fortune 26 group.

This method of choosing risk groups obviously means that there will be no differentiation between residual risk differences in the bond rating classes. All subsidiaries belonging to the same rating group will have the same estimate of equity cost equal to the average for the group. However, this single criterion classification does provide a simple way of obtaining a good first approximation of the subsidiary equity cost.

Having established the risk group we estimate the average of the equity costs of the individual firms in the group using the cost of capital models as discussed earlier. We estimate the individual firm equity costs using:

1. The DCF constant growth model in which the equity cost k is calculated as

$$(k_{DCF})_1 = \frac{D_1}{P_0} + g$$

where

D_1 = dividend in the next period

P_0 = current spot price

$g = b \times r = (1 - POR) \times r$

b = expected retention rate
= 1 - (5-year average payout rate)

r = expected rate of return on book equity, measured as the normalized rate of return, $DPS_0/(POR \times BVS_0)$

2. The DCF non-constant growth model in which the cost of equity, $k = (k_{DCF})_2$, is the solution value of the equation

$$P_0 = \sum_{t=1}^{N} \frac{D_t}{(1 + k)^t} + \frac{D_N(1 + g_N)}{k - g_N}\left(\frac{1}{1 + k}\right)^N$$

where

P_0 = current spot price

N = number of years of transitional growth = 4

D_t = D_1, D_2, D_3, D_4 are the dividends expected in years 1 through 4; D_1 and D_4 are forecast by Value Line; D_2 and D_3 are estimated by interpolating between D_1 and D_4

D_N = dividends expected in year 4, provided by Value Line

g_N = constant growth after year 4
= $b_4 \times r_4$

b_4 = expected retention rate in year 4
= $1 - (DPS_4/EPS_4)$; values of DPS_4 and EPS_4 are forecast by Value Line

r_4 = expected return on equity in year 4

$$= \frac{EPS_4}{(\text{Average } BVS)_4}$$

$$= \frac{EPS_4}{(BVS_3 + BVS_4)/2}$$

BVS_4 is forecast by Value Line. BVS_3 is calculated by interpolating between BVS_1 and BVS_4, both obtained as Value Line forecasts.

3. The CAPM approach in which the cost of equity is estimated as

$$k = E(R) = R_F + \beta[E(R_M) - R_F]$$

where

R_F = risk-free rate, measured as the yield on a 20-year Government bond

β = systematic risk, estimated as the historical beta

$E(R_m) - R_F$ = market risk premium

We use two measures of market risk premiums thus obtaining two estimates of the CAPM cost of equity.

$(k_{CAPM})_1$: based on historical market risk premium provided by Ibbotson and Sinquefield

$(k_{CAPM})_2$: based on expected market risk premium as developed by Brigham and Shome

4. The risk premium approach in which the cost of equity for the risk group, G, is directly measured as

$$k = R_G + \text{risk premium}$$
$$= R_G + [RP]_G$$

where

$[RP]_G$ = average expected risk premium for the risk group, averaged over 5 years, 1977-1981

$= E(R_G) - R_F$

$E(R)_G$ = expected DCF rate of return for the risk group

Again we have two measures of the equity cost for the risk group, depending on how $E(R)_G$ is estimated in calculating the risk premium.

$(k)_{RP_1}$: based on the constant growth DCF measure of $E(R)_G$
$(k)_{RP_2}$: based on the non-constant growth DCF measure of $E(R)_G$

Thus in the analogy approach we choose the comparable risk groups based mainly on matching bond rating and we estimate the equity costs of the firms in the risk group using the DCF, CAPM and risk premium models. For each of these models we obtain two measures of equity costs depending on how the dividend growth rates and risk premiums are measured. Finally there is the question of how the individual equity costs for the risk group companies should be averaged. For the utility groups the difference between a simple average and value weighted average is insignificant and only simple averages will be reported. For the Fortune 25 group, the differences are larger and both averages will be reported. Estimates of subsidiary costs of equity will be made for the period 1977-1981.

The Analytical Approach

In the analytical approach we establish, econometrically, a relationship between equity costs for the comparable risk group and the real determinants of risk. The real determinants, which are the explanatory variables, can be measured using the firm data, thus obviating the need for financial capital market data. The relationship can then be used to estimate the subsidiary cost of equity. Since risk variables are explicitly included in the econometric models, this approach provides unique estimates for each subsidiary. This feature is an advantage over the analogy approach in which risk differentiation is not complete so that all subsidiaries in the same risk group, established on the basis of selected risk criteria, like bond ratings, have the same estimate of equity costs. Another advantage of this methodology is that it provides confidence intervals about the equity cost estimates. The validity of this approach depends upon appropriate model specification and accurate variable measurements. The latter can present serious problems. The trade-off between the analogy and analytical approach is that the former is easy to implement and is relatively free of measurement error while the latter provides a more complete analysis of risk and return but is subject to more serious measurement errors. Within this analytical approach we have developed four econometric models.

An Econometric Model Based on the Real Determinants of Equity Costs

In this model we estimate the relationship between equity costs, k_i, and their real determinants for a broadly defined risk group. For the estimation of subsidiary equity costs of utilities, the total industry sample is chosen as the comparable risk group. For the estimation of equity cost of Western Electric the chosen sample is the Fortune-25 group of large manufacturing companies.

The market-determined required rate of return or cost of equity for a share of stock of firm i is

$$\begin{aligned} k_i &= \text{real rate of return} + \text{inflation premium} + \text{risk premium} \\ &= \text{risk-free rate} + \text{risk premium} \end{aligned}$$

The yield on a default-risk free Government bond provides a measure of the real rate plus the inflation premium. Stockholders require a premium over the risk-free rate to compensate them for the business and financial risk of the firm. This premium is a function of the relevant risk variables. Thus

$$k_i = R_F + f(\text{risk variables})$$

As a cross-sectional regression equation for a sample of firms

$$k_i = a_0 + \sum_{r=1}^{n} a_r X_{r,i} + u_i \tag{3-18}$$

where

X_r = risk variables

a_0 = estimate of the risk-free rate or yield on a Government bond

u_i = error term

Equation (3-18) forms the basis of the alternative model specifications that we use in this approach. Specifically, for the sample of electric utility firms we estimated the following models.

Model M1. For this model we have the following specification:

$$\begin{aligned} k_i = a_0 &+ a_1(\text{business risk})_i + a_2(\text{financial risk})_i \\ &+ a_3(\text{regulatory risk})_i + a_4(\text{fuel mix})_i + u_i \end{aligned} \tag{3-19}$$

The variables in this equation are defined and measured as follows:

k_i: the cost of equity of firm i in the sample. We used cost of equity measures using both the DCF model and the CAPM. For each model we had two estimates of k_i as described in the pure play approach--

$(k_{DCF})_1$ using the constant growth model with normalized growth rates; $(k_{DCF})_2$ using the nonconstant growth model and growth rates from Value Line forecasts; $(k_{CAPM})_1$ with historical market risk measure and $(k_{CAPM})_2$ with expected market premium measure.

(Business risk)$_i$: the business risk, (BR)$_i$, is the variability in operating earnings and or in return on investment, ROI, of firm i. We used two measures of business risk, the total risk and the systematic risk both defined in accounting terms. We measured the total business risk as the standard deviation of return on investment, (SROI), using annual ROI data over a 10-year horizon. We measured systematic business risk as the accounting beta (BROI). As described in the literature survey the accounting beta was measured as the slope coefficient of the time series regression between the firm ROI and the ROI on the market index. We used the S&P 500 firms as the market index. If we assume that all investors hold well-diversified portfolios then the systematic risk as measured by the accounting beta, BROI, is the more relevant measure of business risk. If we assume that investors are concerned with total risk and not just the systematic risk then the total business risk as measured by the standard deviation of returns, SROI, is more appropriate. For either measure we would expect the coefficient of business risk to be positive and significant. The higher the business risk the greater the investors' required rate of return on equity, k_i.

(Financial risk)$_i$: arises from the use of leverage or debt financing. For a given level of business risk or ROI variability, the higher the financial leverage the greater the resulting variability in equity returns, ROE. The variability in ROE is a measure of the total risk or equity risk. We measured financial risk as the equity ratio, (EQR), which is the ratio of book value of equity to total capital. The higher the equity ratio, the lower the financial leverage, the lower the financial risk and the lower the investors' required rate of return. We expect the coefficient of the equity ratio variable to be negative and significant.

(Regulatory risk)$_i$: is the additional element of risk faced by utilities arising from the fact that these firms are regulated and their future returns depend on the not totally predictable actions of regulatory commissions. A measure of regulatory risk is the qualitative ranking of State Regulatory Commissions published, among others, by Salomon Brothers. However, these data are not available prior to 1979, so for this study we have tried to measure, quantitatively, the various elements that constitute regulatory risk. Commission rankings are based primarily on the accounting treatment of construction work in progress, the accounting treatment of depreciation and investment tax credits, and the regulatory lag. Accordingly, we developed three quantitative measures for regulatory risk.

AFUDC/NI: the ratio of allowance for funds used during construction to net income available to shareholders. This ratio represents the proportion of non-cash income in the total income. The higher this ratio the poorer the coverage ratio of the firm, in cash terms, and therefore, the riskier the firm. For electric utilities the size of the construction program is typically very large and the construction period is very long. There are two methods by which the utility is allowed to recover the cost of borrowed funds used during construction. In the rate base method, the construction work in progress (CWIP) is included in the rate base, on which the utility earns a return so that capital costs are recovered from current consumers during the construction period. In the AFUDC method, the CWIP is capitalized with an offsetting non-cash AFUDC account in the income statement. When the plant is completed and goes on-stream, the capital costs accumulated during the entire construction period is recovered from the consumers using the facility, through depreciation charges on the new plant. The argument used to justify the AFUDC method is that current consumers should not be required to pay for capital costs of constructing a plant that will be used by future consumers. It is an intergenerational equity argument. It assumes that current and future users are distinctly independent populations, an assumption that may not be exactly valid. In periods of increasing capital costs the AFUDC method places a heavy burden on utilities. Their cash flow situation deteriorates and their cash coverage of fixed charges and dividends decline. This in turn could cause a downgrading of their bonds resulting in increased capital costs and reduced ability to raise capital. Thus the higher the AFUDC/NI ratio the greater the investor perception of the utility's risk and greater the required rate of return. We would expect the coefficient of this variable to be positive and significant.

Flow through versus normalized: we define a dummy variable FT = 1.0, for utilities that flow through the tax benefits resulting from liberalized tax depreciation and investment tax credits and FT = 0 for utilities that are allowed to normalize or defer these benefits. In flowthrough accounting the benefits are included as reductions of income tax expense in the year realized. The benefits are passed on to the consumers as reduced rates. In normalized accounting, the tax reductions are credited to income over the productive life of the asset. The flowthrough method obviously deprives the utility company of cash flow and thus increases outside fund requirement for plant replacements and extensions. During periods of increasing capital costs faced by utilities since the mid-1970s, firms required to use the flowthrough method would be perceived to be more risky. We would expect the coefficient of this dummy variable, FT, to be positive and significant.

Difference between allowed and earned return on equity: this variable defined as ΔROE, is a measure of regulatory lag. In an inflationary economy, with increasing capital costs, the returns earned on book value are usually lower than the fair rate allowed by the regulators. Between rate hearings, the prices and revenue of a utility are fixed, commensurate with the allowed rate at the last rate hearing. However during the period costs increase with inflation causing profits to be squeezed and reducing the earned return on equity. Over time, the differential between allowed and earned ROE will be smaller for utilities that are regulated with smaller lags; that is, for utilities given justifiably frequent rate relief in recognition of inflating costs. Thus ΔROE is an indirect measure of regulatory lag and the coefficient of this variable is expected to be significantly positive.

$(\text{Fuel mix})_i$: defined as the percentage of the total generation obtained from nuclear power plants. Utilities with a higher percentage of their output from nuclear plants are perceived to be more risky. This is because of the high degree of uncertainty surrounding the future of nuclear energy in the country, specially since the Three Mile Island accident in 1980. This variable, NUK, is also expected to have a positive coefficient, at least since 1980.

A complete specification of Model 1, including the component variables for regulatory risk, would be:

$$k_i = a_0 + a_1(BR)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i$$
$$+ a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + u_i \qquad (3\text{-}20)$$

$\hat{a}_0$ = intercept term, a measure of the risk-free rate; should approximate the yield on long-term Government bonds

We have used four alternative measures for k_i and two for business risk, so we estimate eight regression equations for each annual cross-sectional analysis. We carried out the analysis for five years, 1977-1981, obtaining forty regression estimates.

Model M2. For Model M2 we have the following equation:

$$k_i = a_0 + a_1(\text{equity risk})_i + a_2(AFUDC/NI)_i + a_3(FT)_i$$
$$+ a_4(\Delta ROE)_i + a_5(NUK) + u_i \qquad (3\text{-}21)$$

This specification differs from Model M1 in that the combination of business risk (BR) and financial risk (EQR) has been replaced by total risk or equity risk. All other variables are defined and measured as in Model M2. For equity risk we used two alternative measures, the total equity risk and the systematic equity risk. We measured total equity risk as the standard deviation of return on book equity, (SROE), using annual ROE data over a 10-year horizon. We measured systematic equity risk as the accounting beta (BROE) based on time series data on the ROE for the firm and the S&P 500 index. As in Model M1, we have four measures of k_i and two measures of equity risk providing eight regression equations in each year for the five-year period 1977-1981.

From the estimated Models M1 and M2 we can obtain unique estimates for any electric utility subsidiary. All the explanatory variables can be measured for the subsidiaries because they depend only on firm data and not capital market data. From the estimated regression equations and the measures of the independent variables for the subsidiary, its predicated equity cost can be estimated. This, of course, assumes that the subsidiary belongs to the same population as the industry in which it operates; not an unreasonable assumption.

An Econometric Model Based on the Gordon Valuation Equation

In the econometric models M1 and M2 we specified the cost of equity to be a function of a number of risk variables. The variables chosen are intuitively acceptable as risk variables and the list is quite comprehensive. However, the functional relationship specified is not based on any theory. In other words, these models were not based on any theoretically developed valuation equation that relates value, risk and return. In the present approach we develop an econometric model based on the Gordon equity valuation equation. According to the Gordon model the value or price per share of common stock, P, is related to the expected or required rate of return, k, by the equation

$$P = \frac{D_1}{k - g}$$

D_1, the expected dividend in the next period can be written as follows:

$$D_1 = \text{(expected payout rate)(expected earnings per share)}$$
$$= \text{(EPOR)(EEPS)}$$
$$\text{EPOR} = 1 - \text{expected retention rate}$$
$$= 1 - b$$
$$\text{EEPS} = \text{(current book value per share)(expected return on book equity)}$$
$$= B(\text{EROE})$$

Therefore

$$D_1 = (1 - b)(B)(\text{EROE}) \tag{3-22}$$

The growth rate in dividends, g, is the retention growth rate as described earlier. Therefore

$$g = \text{(retention rate)(expected return on equity)}$$
$$= b(\text{EROE}) \tag{3-23}$$

Substituting Equations (3-22) and (3-23) in the main Gordon equation

$$P = \frac{(1 - b)(B)(\text{EROE})}{k - b(\text{EROE})} \tag{3-24}$$

or

$$\frac{P}{B} = \frac{(1 - b)(\text{EROE})}{k - b(\text{EROE})} \tag{3-25}$$

$$= \frac{-b(\text{EROE})}{k - b(\text{EROE})} + \frac{\text{EROE}}{k - b(\text{EROE})} \tag{3-26}$$

In a cross-sectional regression form, the above equation can be written as

$$(P/B)_i = a_0 + a_1(\text{EROE})_i + u_i \tag{3-27}$$

In Figure 3-1, we show a plot of the relationship between P/B and EROE described by Equation (3-25), for given values of retention rate, b, and the expected market return on equity, k. The relationship between P/B and EROE is nonlinear, so the regression Equation (3-27) specified is valid only under the assumption that approximate linearity holds in the range of values of P/B, b and k for the sample. As can be seen form Figure 3-1 which was plotted for reasonable values, for electric utilities, of the retention rate (35%) and cost of equity (16%), the relationship is approximately linear for firms with P/B ratios in the reasonable range of 0.8 to 1.2.

If all the firms in the sample had the same required rate of return, k, they would plot exactly on the curve shown in Figure 3-1. However risk differentials among firms do exist so that the firms in the sample will plot above and below the line. For firms with the same expected rate of return, EROE, the ones with the average required rate will plot on the line, the ones with lower required rates will have a higher than average P/B value and will plot above the line. By the same argument firms with greater than average risk will plot below the line. Figure 3-2 depicts the relationship between P/B and EROE as described by the regression Equation (3-27) in the presence of differential risks in the sample.

To account for risk differentials among firms in the sample we modify the simple linear regression Equation (3-27) to explicitly include risk variables in the specification. Thus the final model specification is of the form

$$(P/B)_i = a_0 + a_1(EROE)_i + \sum_{r=2}^{n} a_r X_{r,i} + u_i \qquad (3\text{-}28)$$

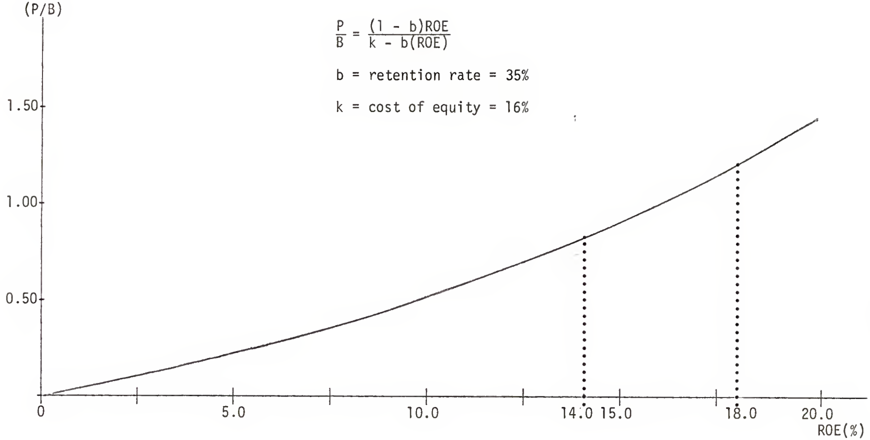

Figure 3-1
Plot of the P/B Ratio Against
Expected Return on Book Equity

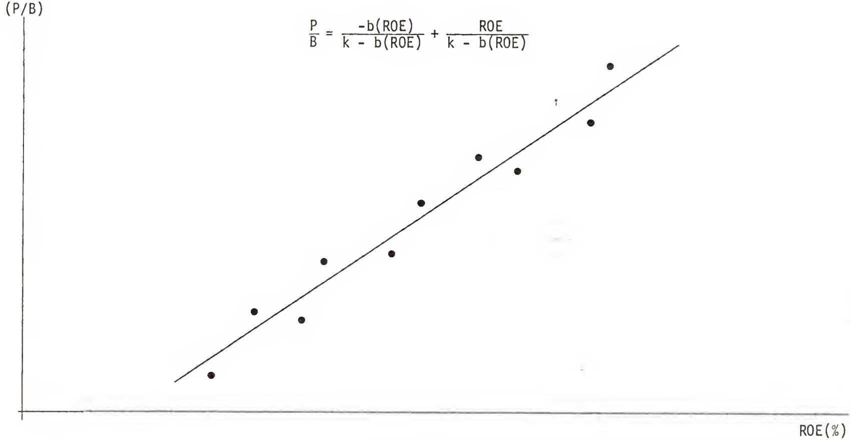

Figure 3-2
Plot of Regression Equation 3-27

where

X_r = risk variables

The risk variables chosen are the same as specified in Model 2. Specifically the econometric model based on the Gordon valuation equation is specified as Model M3:

$$(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + u_i \qquad (3\text{-}29)$$

We defined and measured the variables in this model as follows:

$(P/B)_i$: we measured the price/book ratio as the ratio of year-end spot price to book value per share.

$(EROE)_i$: we used three alternative measures of the expected rate of return on book equity. (1) NROE: the normalized rate of return, described earlier and measured as $DPS_0/(POR \times BVS_0)$. (2) PROE: the predicted ROE, measured as the forecast ROE from a time-trend regression of ROE against time using 15 years annual return data. (3) IVROE: the instrumental variable ROE, using a two-stage regression to purge the measurement error associated with using current ROE as a measure of expected ROE. The instrumental variables used in the first stage to "explain" current ROE were ROE realized in the previous year, ROE_{-1}, the ROE currently allowed, AROE, and the current equity ratio, EQR.

$$(ROE)_i = a_0 + a_1(ROE_{-1})_i + a_2(AROE)_i + a_3(EQR)_i + u_i \qquad (3\text{-}30)$$

From this first stage regression the predicted ROE is used as the measure of IVROE used in the main regressions.

All other variables: as described in Model M2.

Thus for Model M3 we have two measures of equity risk, SROE and BROE, and three measures of expected return on equity, NROE, PROE and IVROE, resulting in six regression equation estimates in each year for the five years analyzed, 1977-1981.

The risk variables included in Model M3 apply to a sample of electric utility firms. When this methodology is used to estimate equity costs of telephone subsidiaries and for Western Electric, obviously not all the risk variables are relevant. For these subsidiaries we use model specification M4.

Model M4. For Model M4 we have the following equation:

$$(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + u_i \qquad (3\text{-}31)$$

Again, we use three alternative measures of EROE and two alternative measures of equity risk for the analysis covering the period 1977-1981.

Estimation of the Subsidiary Cost of Equity. From the estimated regression equations described by Models M3 and M4, we can calculate the cost of equity of the parent and subsidiary firms and predict the market value of the subsidiary. Equation (3-25) forms the theoretical basis for calculating the cost of equity from the estimated regressions. From this equation

$$\frac{P}{B} = \frac{(1 - b)(EROE)}{k - b(EROE)} \qquad (3\text{-}25)$$

it can be readily seen that when k = EROE, P/B = 1.0. This implies that when a firm is expected to earn a rate of return on equity, EROE, exactly equal to its cost of equity capital, k, its P/B ratio will be 1.0.

For competitive firms earning returns equal to capital costs, the market value of the firm is equal to the book value of the assets and P/B = 1.0. For monopolistic firms, earning monopoly rents with EROE greater than k, the P/B ratio is greater than 1.0. Utilities are regulated with the objective of allowing them to earn their cost of capital. If commissions did allow fair rates of return equal to the cost of capital and investors expected utilities to earn these returns, then all utilities would, like competitive firms, have P/B ratios equal to 1.0. To the extent that allowed rates are different from capital costs and regulatory lags prevent utilities from earning the fair rate, the P/B ratios will be different from 1.0. Since the mid-1970s regulatory relief has not kept pace with increasing capital costs in an inflationary economy and the average P/B ratio for the industry has been less than 1.0. In any event, the model specifications provide an explicit relationship between P/B ratios and expected return on equity. Thus by setting P/B = 1.0, and solving the equation for EROE, the equity cost for the firms in the sample and the subsidiaries belonging to the same population, can be calculated. The solution value of EROE, corresponding to P/B = 1.0, is the cost of equity.

Estimation of Market Value of Subsidiaries. The prediction of the market values of equity of the subsidiaries involves two steps:

1. From the estimated regression equation, and the values of all the independent variables, the dependent value $(\widehat{P/B})$ can be predicted.
2. Knowing the book value of equity of the subsidiaries their market values can be predicted as

$$\text{Estimated market value} = \widehat{MV} = (\widehat{P/B})(\text{book value of equity})$$

In the first step we see that to predict $(\widehat{P/B})$ for the subsidiaries we need to be able to measure all the independent variables. This precludes the measure of EROE as the normalized rate of return, NROE. As defined and measured, NROE = $DPS_0/(BVS_0 \times POR)$, depends on capital market data for measures of DPS and the payout rate. These data are not available for subsidiaries. Thus to measure subsidiary cost of equity which is obtained as a solution value of EROE, all three measures of EROE, projected, normalized and instrumental variable are admissable. However, to predict $(\widehat{P/B})$ and $\widehat{MV}$ for subsidiaries which require the measurement of EROE, only two measures, PROE and IVROE, that depend on only firm data, are admissable.

Testing for the Validity of the Estimates. Traditional finance theory assumes risk independence; that is, the value of the firm is the sum of the values of its component parts and there is no intrinsic value to diversification by the firm. According to this Value Additivity Principle

$$V_p = \sum_{i=1}^{N} V_i \qquad (3\text{-}32)$$

and

$$k_p = \sum_{i=}^{N} X_i k_i \qquad (3\text{-}33)$$

where

V_p = observed market value of equity of the parent company

V_i = market value of subsidiary i

N = number of subsidiaries

k_p = equity cost of the parent

k_i = equity cost of subsidiary i

X_i = market value weight = V_i/V

The validity of the estimates of the subsidiary cost of equity and market values can be tested by testing for the equalities represented by Equation 3-32 and Equation 3-22. In the absence of significant synergies, the subsidiary estimates will be validated if the observed market value of the parent is equal to the sum of the estimated market values of all its subsidiaries and if the estimated equity cost of the parent is equal to the weighted average value of the estimated capital costs of all its subsidiaries; the weights being the estimated market value weights. Fuller and Kerr (1981) tried a similar approach, however their methodology did not allow them to estimate market values of subsidiaries so they used sales fraction as an approximation of equity market value fraction.

An Econometric Approach Based on the CAPM

In the previous section we developed an econometric model based on the Gordon valuation equation. Litzenberger (1969) and Litzenberger and Rao (1971) have developed a similar model based on the CAPM which we have adapted to estimate subsidiary capital costs. According to the CAPM the required rate of return on an equity share, k_i, is a linear function of the non-diversifiable systematic risk:

$$\begin{aligned} k_i &= R_F + \beta_i[E(R_m) - R_F] \\ &= R_F + \frac{\operatorname{cov}(R_i,R_m)}{\operatorname{var}(R_m)}[E(R_m) - R_F] \end{aligned}$$

$$= R_F + r_{im} \frac{\sigma_i \sigma_m}{\sigma_m^2}[E(R_m) - R_F]$$

$$= R_F + [\frac{E(R_m) - R_F}{\sigma_m}] r_{im}\sigma_i$$

$$= R_F + b(r_{im}\sigma_i) \qquad (3\text{-}34)$$

where

R_f = risk-free rate

β_i = measure of systematic risk

$= \frac{cov(R_i, R_m)}{var(R_m)}$

$E(R_m)$ = expected return on the market portfolio

σ_i, σ_m = standard deviations of returns on equity of firm i and on the market portfolio, respectively

r_{im} = correlation coefficient between return on i and m

$b = \frac{E(R_m) - R_F}{\sigma_m}$

= marginal required rate of return per unit of nondiversifiable risk as measured by $r_{im}S_i$; b is constant for all firms

$r_{im}\sigma_i$ = measure of nondiversifiable risk for the ith share

Equation (3-34) holds under the usual assumptions underlying the CAPM--perfect capital market dominated by risk averse investors who share homogeneous expectations and can borrow and lend at the risk-free rate. Under the further assumption of no future growth the price per share, P_i, of the ith firm will be the present value of the perpetual stream of earnings to the ith share

$$P_i = \frac{E_i}{k_i} \qquad (3\text{-}35)$$

where

E_i = expected value of earnings to equity for the ith firm

k_i = required rate of return for the equity of the ith firm

The nondiversifiable risk inherent in an equity share may then be expressed as

$$\begin{aligned} D_i &= \frac{\text{nondiversifiable risk of the earnings stream}}{\text{market price of the firm's equity}} \\ &= \frac{r_{im}\sigma_{E_i}}{P_i} \qquad (3\text{-}36) \end{aligned}$$

By substituting Equation (3-36) into Equation (3-34) and the resulting equation into (3-35) we get

$$\begin{aligned} P_i &= \frac{E_i - br_{im}\sigma_{Ei}}{R_F} \qquad (3\text{-}37) \\ &\equiv \frac{\text{Certainty equivalent of risk}}{\text{risk-free rate}} \end{aligned}$$

Now, if the assumption of no growth is relaxed, a growth term is added to Equation (3-37) to account for addition to the value of the firm from future investment opportunities that earn rates of return in excess of its cost of capital. The growth model developed by Miller and Modigliani (1966) is used. In this model it is assumed that the firm has profitable investment opportunities for a finite number of years T, during which it is expected to earn a constant rate of return on book equity, ROE, in excess of the cost of capital. During this period the dollar amount of equity investment is a fixed proportion of the firm's expected earnings. After T years, the firm earns returns equal to the cost of equity. Under these assumptions Miller and Modigliani approximated the net present value of future earnings growth by

$$G_i = [\frac{\Delta B_i(ROE_i - k_i)}{k_i(1 + k_i)}]T \tag{3-38}$$

where

ΔB_i = equity investment in firm i during the year.

Combining Equations (3-37) and (3-38)

$$P_i = \frac{E_i - br_{im}\sigma_{E_i}}{R_F} + [\frac{\Delta B_i(ROE_i - k_i)}{k_i(1 + k_i)}]T \tag{3-39}$$

After deflating by book value per share to correct for possible heteroskelasticity the regression form of Equation (3-39) is

$$(\frac{P}{B})_i = \frac{ROE_i}{R_F} - \frac{br_{im}\sigma ROE_i}{R_F} + [\frac{g_i(ROE_i - k_i)}{k_i(1 + k)}]T + U_i \tag{3-40}$$

or

$$(\frac{P}{B})_i = \alpha_1(ROE)_i + \alpha_2(\sigma_{ROEi}) + \alpha_3[\frac{g_i(ROE_i - k)}{k(1 + k)}] + U_i \tag{3-41}$$

where

$\hat{\alpha}_1 = 1/R_F$ = marginal rate of time preference

$\hat{\alpha}_2 = (-br_{im})/R_F$

= marginal required rate for a unit of standard deviation; a measure of risk aversion

$\hat{\alpha}_3 = T$

= number of future years of profitable investment during which the firms earn returns in excess of capital costs

In making the transition from the theoretical Equation (3-39) to the regression Equation (3-40), Litzenberger and Rao make the following assumption:

1. The correlation coefficient, r_{im}, for all firms is a constant and therefore can be captured by the regression coefficient.
2. The industry average cost of equity, k, can be used to estimate the growth term for all firms.

They hypothesize:

$\hat{\alpha}_1 > 0$ and equal to $1/R_F$

$\hat{\alpha}_2 < 0$ indicating risk aversion

$\hat{\alpha}_3 > 0$ indicating opportunities for excess profits from future investments

From the estimated regression equation they estimate the cost of equity for each firm as

$$k_i = R_F + (br_{im})\sigma_{ROE_i}$$

$$= \frac{1}{\hat{\alpha}_1} - \frac{\hat{\alpha}_2}{\hat{\alpha}_1}\sigma_{ROE_i} \qquad (3\text{-}41)$$

Their model is obviously amenable to estimating the cost of equity of subsidiary firms. From the estimates of the regression coefficient $\hat{\alpha}_1$ and $\hat{\alpha}_2$ and a measure of $(\sigma_{ROE})_i$ for the subsidiary firms, Equation (3-42) can be used to estimate the subsidiary cost of equity.

In adapting the Litzenberger & Rao model to estimate subsidiary equity costs we used two alternative model specifications. The first specification was an exact replication of their model using their techniques for measuring all the variables. The second was a modified specification to correct for some of their assumptions. In the modified specification, the measurement techniques were also different from those used by Litzenberger and Rao.

Model M5. Model M5 is a replication of the Litzenberger and Rao model.

$$\left(\frac{P}{B}\right)_i = \alpha_1(ROE)_i + \alpha_2(\sigma_{ROE})_i + \alpha_3\left[\frac{g_i(ROE_i - k)}{k(1 + k)}\right]_i + U_i$$

where

$(ROE)_i$ = expected return on equity, measured as an average of 7 years historical returns

$(\sigma_{ROE})_i$ = expected standard deviation of returns on equity, measured using 7 years historical return data

g_i = expected growth in book value, measured as a 7-year historical growth rate

k = industry cost of capital, measured as $k = D_1/P + g$, for the Moody's Utility Index. Again g was measured as a 7-year historical growth rate in dividends.

The use of historical measures for all the independent variables may result in serious measurements errors and biased coefficients which in turn would result in biased estimates of the subsidiary equity costs. In the modified version of the Litzenberger and Rao model we have attempted to correct for some of the measurement error. We have also corrected for their assumption that the correlation coefficient r_{im} is constant by including it in the variable rather than in the regression coefficient. Thus

Model M6. Model M6 is a modified Litzenberger and Rao model.

$$\left(\frac{P}{B}\right)_i = \alpha_1 (\mathrm{ROE})_i + \alpha_2 (r_{im}\sigma_{\mathrm{ROE}})_i + \alpha_3\left[\frac{g_i(\mathrm{ROE}_i - k)}{k(1 + k)}\right]_i + U_i$$

We used the following measurements for the variables:

$(\mathrm{ROE})_i$: the three alternative measures used in the Gordon model were used--the normalized ROE, the projected ROE and the instrumental variable ROE

$(r_{im}\sigma_{\mathrm{ROE}})_i$: was proxied by the accounting ROE beta coefficient (BROE) and measured as described in model M2.

g_i: was measured as the 5-year Value Line projection for future growth in book value

k: was measured as the average cost of equity value, as measured by the non-constant growth DCF model, for the entire industry

Like the econometric model based on the Gordon equation, Model M6 can also be used to predict the market value of subsidiaries and is therefore amenable to the validity tests based on the Value Additivity Principle.

Econometric Model Based on the Theory of the Firm

As described in the literature survey, Subrahmanyam and Thomadakis (1980) and Chiang and Goldenberg (1980), developed a theoretical relationship between the systematic risk of a firm and its micro-variables. Specifically they found the beta coefficient to be a function of a firm's labor/capital ratio and monopoly power.

$$\beta_i = 1 + \frac{(1 - U_i)wy_i(\sigma_e^2 - \sigma_{ev}^2)}{\sigma_e^2[(1 + r) + x_2U_iwy_i]}$$

where

β_i = firm beta

U_i = 1/Price elasticity of demand

$\frac{1}{1 - U_i}$ = Lerner's index of monopoly power

$y_i = L_i/K_i$ = labor to capital ratio

σ_e^2 = uncertainty in output prices

σ_{ev}^2 = covariance between price and wage uncertainty

$x_2 = 1 - hS\sigma_{ev}^2$

h = market price of risk

$S = \Sigma p_iq_i$ = market revenue

r = risk-free rate

w = expected wage rate

Of these variables only U_i, y_i and β_i are firm specific, so that in a cross-sectional analysis

$$\beta_i = 1 + \frac{a_0f(MP)(L_i/K_i)}{a_1 + a_2f(MP)(L_i/K_i)} \tag{3-44}$$

where

f(MP) = function of monopoly power

Thus Equation (3-44) is a non-linear relationship between firm beta, its monopoly power and factor proportions.

The model is theoretically appealing but the problems of accurately measuring factor proportions and monopoly power are overwhelming. As a first approximation we specified a linear regression equation.

Model M7. For Model M7 we have the following specification:

$$\beta_i = a_0 + a_1(\text{labor/capital})_i + a_2(\text{monopoly power})_i + U_i \quad (3\text{-}45)$$

If this model can be estimated with reasonable accuracy, it can be used to measure the systematic risk of subsidiaries. We tried to estimate the model for a sample of electric utilities using the following approximate measures of the independent variables:

$$\text{Labor-capital ratio} = \frac{\text{average number of employees}}{\text{net generating capacity}}$$

$$\text{Monopoly power} = \frac{\text{price - marginal cost}}{\text{price}}$$

$$= \frac{\text{sales - operating expenses}}{\text{sales}}\text{; assuming marginal}$$

cost = average cost

We measured the dependent variable as the utility's unlevered beta using the Hamada equation.

Summary

In this chapter we described the theoretical and empirical framework for estimating the cost of equity of subsidiary firms. To estimate the cost of equity of the electric utility subsidiaries we used all the methodologies developed in the chapter. In the pure play or analogy approach we used the bond rating as a criterion for establishing the comparable risk group. To estimate the average cost of equity for the risk group we used the DCF model, the CAPM and the risk premium approach. In the analytical approach we developed four econometric models to estimate the subsidiary cost of equity. In the first model a relationship was estimated between the equity cost of the electric utilities and their real determinants of risk. From this estimated equation the subsidiary equity cost can be estimated. The second econometric model was based on the Gordon valuation equation. This model is used to predict the equity costs and market value of the subsidiaries. The latter feature allows us to test for the validity of the equity cost estimate under the assumption of value additivity. In this test we compare the cost of equity of the parent to the weighted average cost of equity of the subsidiaries, the weights being equity market value weights. The third model, developed by Litzenberger and Rao (1971) is based on the CAPM. Finally, we attempted to estimate a model based on the theory of the firm as developed by Subrahmanyam and Thomadakis (1980). In this model the firm's systematic risk is a function of its factor proportions and monopoly power. Based on this analysis for the electric utilities only those methodologies and measurement techniques found acceptable in terms of the model estimates and resulting equity cost estimates, will be applied to Western Electric and the telephone subsidiaries.

In the following chapter we present and analyze the empirical results.

CHAPTER IV
EMPIRICAL RESULTS AND DISCUSSION

In this chapter we present the empirical results, computations of subsidiary capital costs and a critical discussion of the results. We present the analyses for Electric Utility subsidiaries, Western Electric which is an unregulated subsidiary of AT&T and for Telephone subsidiaries, in that order.

Estimation of Capital Costs of Electric Utility Subsidiaries

To estimate the cost of equity capital of Electric Utility subsidiaries we used all the methodologies developed in Chapter Three. Based on the analysis of the model estimates and the resulting capital cost estimates, we reject those models that produce "unreasonable" results. Only those models that survive the reasonableness criterion will be used to estimate the equity costs of Telephone subsidiaries and Western Electric. For Electric Utilities, we will illustrate the use of the models to estimate, specifically, the equity costs of the subsidiaries of Southern Company, American Electric Power and Middle South Utilities for each of the years 1977 to 1981. Table 4-1 lists the subsidiaries of these holding companies. The reason for choosing this group of parent companies is that their subsidiaries listed approximate the sum total of all their equity assets. This requirement is particularly important for carrying out the Value Additivity test for the equality of the value of the parent and the sum of the values of the subsidiaries.

Table 4-1
Subsidiaries of Southern Company
American Electric Power and
Middle South Utilities

Parent Company	Subsidiaries
Southern Company	Alabama Power Georgia Power Gulf Power Mississippi Power
American Electric Power	Appalachian Power Columbus and Southern Ohio Indiana and Michigan Electric Kentucky Power Ohio Power
Middle South Utilities	Arkansas Power and Light Louisiana Power and Light New Orleans Public Service Mississippi Power and Light

Estimates of Subsidiary Equity Costs Using the Pure-Play Approach

As discussed in the previous chapter, the criterion used to establish the comparable risk group is bond rating. In Table 4-2 we show the bond ratings of the subsidiaries of Southern Company, American Electric Power and Middle South Utilities in each of the years 1977 to 1981. In Table A-1 in the appendix we list the traded electric utilities that constitute the various risk groups in each of the years 1977 to 1981. The cost of equity capital for the subsidiaries in each year is then estimated as the average of the equity costs of the comparable risk groups. As discussed in the previous chapter we measured the cost of equity of the individual firms in the risk groups using the DCF model, CAPM and the risk premium approach. In Table A-2 we show the average cost of equity of the samples of firms in the various bond classes. In

Table 4-2
S&P Bond Ratings of Subsidiaries,
1977-1981

Company	1977	1978	1979	1980	1981
Southern Company Subsidiaries:					
Alabama Power	BBB	BBB	BBB	BBB	BBB
Georgia Power	BBB	BBB	BBB	BBB	BBB
Gulf Power	AA	AA	A	A	A
Mississippi Power	A	A	A	A	A
American Electric Power Subsidiaries:					
Appalachian Power	BBB	BBB	BBB	BBB	BBB
Columbus and Southern Ohio	BBB	BBB	BBB	BBB	BBB
Indiana and Michigan Electric	BBB	BBB	BBB	BBB	BBB
Kentucky Power	A	A	A	A	A
Ohio Power	BBB	BBB	BBB	BBB	BBB
Middle South Utilities:					
Arkansas Power and Light	A	A	BBB	BBB	BBB
Louisiana Power and Light	A	A	BBB	BBB	BBB
New Orleans Public Service	A	A	A	BBB	BBB
Mississippi Power and Light	A	A	A	BBB	BBB

Tables 4-3 to 4-7 we present the cost of equity estimates for the selected subsidiary firms in each of the years 1977 to 1981. In Tables 4-8 and 4-9 we present the risk premiums applicable to each risk group. We estimate the risk premium, for each risk class, as the average of the premiums prevailing in the years 1977 to 1981. We calculate the premium in each year, for each risk class, as the difference between the average DCF cost of equity for the risk group and the yield to maturity of bonds with the risk class rating. Finally we use the average risk premium as a measure of ex-ante premiums to estimate the subsidiary equity costs for a future period. The cost of equity for the subsidiaries can be estimated at any point in time by adding the ex-ante premium to the prevailing yield to maturity on its bonds. In Table 4-10 we show the estimates of the subsidiary equity costs for the next year, 1982.

Table 4-3
Pure Play Estimates of Subsidiary
Equity Costs, 1977

Company	Bond Rating	Equity Costs k_1	k_2	k_3	k_4
Southern Company Subsidiaries:					
Alabama Power	BBB	11.51%	13.00%	12.36%	12.10%
Georgia Power	BBB	11.51	13.00	12.36	12.10
Gulf Power	AA	11.86	13.11	12.27	12.01
Mississippi Power	A	11.92	13.44	12.68	12.39
American Electric Power Subsidiaries:					
Appalachian Power	BBB	11.51%	13.00%	12.36%	12.10%
Columbus and Southern Ohio	BBB	11.51	13.00	12.36	12.10
Indiana and Michigan Electric	BBB	11.51	13.00	12.36	12.10
Kentucky Power	A	11.92	13.44	12.68	12.39
Ohio Power	BBB	11.51	13.00	12.36	12.10
Middle South Utilities:					
Arkansas Power and Light	A	11.92%	13.44%	12.68%	12.39%
Louisiana Power and Light	A	11.92	13.44	12.68	12.39
New Orleans Public Service	A	11.92	13.44	12.68	12.39
Mississippi Power and Light	A	11.92	13.44	12.68	12.39

Notes: k_1 is based on constant growth DCF model with normalized growth measures.

k_2 is based on non-constant growth DCF model using Value Line forecasts for growth.

k_3 is based on CAPM with historical measures of market risk premium.

k_4 is based on CAPM with expected market risk premium measures.

Table 4-4
Pure Play Estimates of Subsidiary
Equity Costs, 1978

Company	Bond Rating	Equity Costs k_1	k_2	k_3	k_4
Southern Company Subsidiaries:					
Alabama Power	BBB	13.76%	14.80%	12.85%	12.99%
Georgia Power	BBB	13.76	14.80	12.85	12.99
Gulf Power	AA	13.28	14.47	12.79	12.41
Mississippi Power	A	13.39	14.76	13.25	13.41
American Electric Power Subsidiaries:					
Appalachian Power	BBB	13.76%	14.80%	12.85%	12.99%
Columbus and Southern Ohio	BBB	13.76	14.80	12.85	12.99
Indiana and Michigan Electric	BBB	13.76	14.80	12.85	12.99
Kentucky Power	A	13.39	14.76	13.25	13.41
Ohio Power	BBB	13.76	14.80	12.85	12.99
Middle South Utilities:					
Arkansas Power and Light	A	13.39%	14.76%	13.25%	13.41%
Louisiana Power and Light	A	13.39	14.76	13.25	13.41
New Orleans Public Service	A	13.39	14.76	13.25	13.41
Mississippi Power and Light	A	13.39	14.76	13.25	13.41

Notes: k_1 is based on constant growth DCF model with normalized growth measures.

k_2 is based on non-constant growth DCF model using Value Line forecasts for growth.

k_3 is based on CAPM with historical measures of market risk premium.

k_4 is based on CAPM with expected market risk premium measures.

Table 4-5
Pure Play Estimates of Subsidiary
Equity Costs, 1979

Company	Bond Rating	Equity Costs k_1	k_2	k_3	k_4
Southern Company Subsidiaries:					
Alabama Power	BBB	15.05%	16.15%	14.63%	14.99%
Georgia Power	BBB	15.05	16.15	14.63	14.99
Gulf Power	A	14.96	16.14	14.75	15.07
Mississippi Power	A	14.96	16.14	14.75	15.07
American Electric Power Subsidiaries:					
Appalachian Power	BBB	15.05%	16.15%	14.63%	14.99%
Columbus and Southern Ohio	BBB	15.05	16.15	14.63	14.99
Indiana and Michigan Electric	BBB	15.05	16.15	14.63	14.99
Kentucky Power	A	14.96	16.14	14.75	15.07
Ohio Power	BBB	15.05	16.15	14.63	14.99
Middle South Utilities:					
Arkansas Power and Light	BBB	15.05%	16.15%	14.63%	14.99%
Louisiana Power and Light	BBB	15.05	16.15	14.63	14.99
New Orleans Public Service	A	14.96	16.14	14.75	15.07
Mississippi Power and Light	A	14.96	16.14	14.75	15.07

Notes: k_1 is based on constant growth DCF model with normalized growth measures.

k_2 is based on non-constant growth DCF model using Value Line forecasts for growth.

k_3 is based on CAPM with historical measures of market risk premium.

k_4 is based on CAPM with expected market risk premium measures.

Table 4-6
Pure Play Estimates of Subsidiary
Equity Costs, 1980

		Equity Costs			
Company	Bond Rating	k_1	k_2	k_3	k_4
Southern Company Subsidiaries:					
Alabama Power	BBB	16.16%	17.20%	14.73%	14.51%
Georgia Power	BBB	16.16	17.20	14.73	14.51
Gulf Power	A	16.00	16.87	14.43	14.24
Mississippi Power	A	16.00	16.87	14.43	14.25
American Electric Power Subsidiaries:					
Appalachian Power	BBB	16.16%	17.20%	14.73%	14.51%
Columbus and Southern Ohio	BBB	16.16	17.20	14.73	14.51
Indiana and Michigan Electric	BBB	16.16	17.20	14.73	14.51
Kentucky Power	A	16.00	16.87	14.43	14.24
Ohio Power	BBB	16.16	17.20	14.73	14.51
Middle South Utilities:					
Arkansas Power and Light	BBB	16.16%	17.20%	14.73%	14.51%
Louisiana Power and Light	BBB	16.16	17.20	14.73	14.51
New Orleans Public Service	BBB	16.16	17.20	14.73	14.51
Mississippi Power and Light	BBB	16.16	17.20	14.73	14.51

Notes: k_1 is based on constant growth DCF model with normalized growth measures.

k_2 is based on non-constant growth DCF model using Value Line forecasts for growth.

k_3 is based on CAPM with historical measures of market risk premium.

k_4 is based on CAPM with expected market risk premium measures.

Table 4-7
Pure Play Estimates of Subsidiary
Equity Costs, 1981

Company	Bond Rating	Equity Costs			
		k_1	k_2	k_3	k_4
Southern Company Subsidiaries:					
Alabama Power	BBB	16.25%	17.31%	16.19%	15.42%
Georgia Power	BBB	16.25	17.31	16.19	15.42
Gulf Power	A	15.57	16.86	16.18	15.41
Mississippi Power	A	15.57	16.86	16.18	15.41
American Electric Power Subsidiaries:					
Appalachian Power	BBB	16.25%	17.31%	16.19%	15.42%
Columbus and Southern Ohio	BBB	16.25	17.31	16.19	15.42
Indiana and Michigan Electric	BBB	16.25	17.31	16.19	15.42
Kentucky Power	A	15.57	16.86	16.18	15.41
Ohio Power	BBB	16.25	17.31	16.19	15.42
Middle South Utilities:					
Arkansas Power and Light	BBB	16.25%	17.31%	16.19%	15.42%
Louisiana Power and Light	BBB	16.25	17.31	16.19	15.42
New Orleans Public Service	BBB	16.25	17.31	16.19	15.42
Mississippi Power and Light	BBB	16.25	17.31	16.19	15.42

Notes: k_1 is based on constant growth DCF model with normalized growth measures.

k_2 is based on non-constant growth DCF model using Value Line forecasts for growth.

k_3 is based on CAPM with historical measures of market risk premium.

k_4 is based on CAPM with expected market risk premium measures.

Table 4-8
Risk Premiums for the Risk Groups with Constant Growth DCF Measures of Equity Costs, k_1

	Bond Rating: AA			Bond rating: A			Bond Rating: BBB		
Year	k_1	k_d	Risk Premium	k_1	k_d	Risk Premium	k_1	k_d	Risk Premium
1977	11.86%	8.67%	3.19%	11.92%	8.81%	3.11%	11.51%	8.99%	2.52%
1978	13.28	9.57	3.71	13.39	9.75	3.64	13.76	10.11	3.65
1979	14.62	11.24	3.38	14.96	11.47	3.49	15.05	12.14	2.91
1980	16.08	13.28	2.80	16.00	13.39	2.61	16.16	14.58	1.59
1981	15.96	15.38	0.58	15.57	15.66	-0.09	16.25	16.54	-0.25
Average premium, RP1:			2.73%			2.55%			2.08%

Table 4-9
Risk Premiums for the Risk Groups with Nonconstant Growth DCF Measures of Equity Costs, k_2

	Bond Rating: AA			Bond rating: A			Bond Rating: BBB		
Year	k_2	k_d	Risk Premium	k_2	k_d	Risk Premium	k_2	k_d	Risk Premium
1977	13.11%	8.67%	4.44%	13.44%	8.81%	4.63%	13.00%	8.99%	4.01%
1978	14.47	9.57	4.90	14.76	9.75	5.01	14.80	10.11	4.70
1979	15.70	11.24	4.46	16.14	11.47	4.67	16.15	12.14	4.01
1980	17.04	13.28	3.76	16.87	13.39	3.48	17.20	14.58	2.62
1981	16.59	15.38	1.21	16.86	15.66	1.20	17.31	16.54	0.77
Average premium, RP2:			3.75%			3.80%			3.22%

Table 4-10
Pure Play Estimates of Subsidiary Equity Costs
in 1982, Using the Risk Premium Approach

Subsidiaries	Bond Rating	Bond Yield	Equity Cost			
			RP1	k_1	RP2	k_2
Southern Company:						
Alabama Power	BBB	12.94%	2.08%	15.02%	3.22%	15.94%
Georgia Power	BBB	12.94	2.08	15.02	3.00	15.94
Gulf Power	A	12.21	2.55	14.76	3.66	15.87
Mississippi Power	A	12.21	2.55	14.76	3.66	15.87
American Electric Power:						
Appalachian Power	BBB	12.94%	2.08%	15.02%	3.00%	15.94%
Columbus & Southern Ohio	BBB	12.94	2.08	15.02	3.00	15.94
Indian & Michigan Electric	BBB	12.94	2.08	15.02	3.00	15.94
Kentucky Power	A	12.21	2.55	14.76	3.66	15.87
Ohio Power	BBB	12.94	2.08	15.02	3.00	15.94
Middle South Utilities':						
Arkansas Power & Light	BBB	12.94%	2.08%	15.02%	3.00%	15.94%
Louisiana Power & Light	BBB	12.94	2.08	15.02	3.00	15.94
New Orleans Public Service	BBB	12.94	2.08	15.02	3.00	15.94
Mississippi Power & Light	BBB	12.94	2.08	15.02	3.00	15.94

Based on the analysis of the methodology and the results obtained, we can make the following points regarding the pure play approach:

1. The validity of the estimates of the subsidiary cost of equity depends upon the appropriateness of the comparable risk group chosen and the accuracy of the estimate of the average cost of capital for the risk group.
2. As can be seen from Tables 4-3 to 4-7, there is significant variability in the subsidiary equity cost estimates depending on the choice of the model and measurement techniques to estimate the average cost of equity of the risk groups.

3. There is no purely objective criterion for choosing the "best" estimation model and measurement technique since this methodology does not provide statistical properties for the estimates. The estimation error is not quantified.
4. In the absence of a statistical criterion for accepting a particular estimate, one has to resort to a reasonableness criterion. If it can be reasonably assumed that the risk group with the lower-rated bond is riskier and therefore has a higher required rate of return on equity, then the reasonableness criterion would be that the costs of equity of the risk classes increase as the rating decrease from AA to A to BBB. The estimation model and measurement technique that violates this criterion are unacceptable.
5. From Tables 4-3 to 4-7 it can be seen that the CAPM estimates are generally inconsistent with the reasonable expectation of higher equity costs for subsidiaries with lower-rated bonds. In three out of five year the CAPM estimates of equity cost for BBB-rated subsidiaries are lower than for A-rated subsidiaries, and in one year there is no different between the two. This finding is consistent with the empirical observation that historical betas, used in the CAPM, underestimate the "true" betas for high-beta stocks and overestimate them for lower-beta stocks. The DCF models, both constant growth and non-constant growth, violated the criterion in only one year, 1977.
6. The risk premium approach which adds a risk premium to the prevailing bond yield to obtain the cost of equity for the risk group

depends on the on the existence of a stable premium over time. From the risk premium values in Tables 4-9 and 4-10 we see a downward trend over time, with an inverse relationship between interest rate and risk premium. It is therefore inappropriate to use the simple averages of these values as a measure of the ex-ante risk premiums. The risk premium approach could be applicable if premiums were estimated over a longer horizon encompassing a whole business cycle. Alternatively one could estimate an explicit relationship between risk premiums and interest rates or yields. From this relationship the appropriate premium could be estimated for the prevailing interest rates on bonds and added to the bond yield to obtain equity costs. This is an area for further research. We would expect an inverse relationship between risk premiums and interest rates.

During the period analyzed in this study, 1977 to 1981, interest rates increased and risk premiums declined, and was even negative in 1981. The magnitude of the risk premium is expected to depend on the relative hedging properties of stocks and bonds against anticipated and unanticipated inflation. Both stocks and bonds can hedge against anticipated inflation but whereas bonds provide no hedge against unanticipated inflation, stocks are expected to provide at least a partial hedge against unanticipated inflation. Therefore, during periods of high unanticipated inflation, associated with high interest rates (see Gordon and Halpern, 1976), the required rate of return on stocks decline vis-a-vis that on bonds resulting in a reduced risk premium.

7. Finally, as discussed earlier, the use of a single criterion, the bond rating, to choose the comparable risk groups does not permit the complete differentiation between risk and return of the subsidiaries being analyzed. There is a tradeoff involved in using multiple risk criteria, between increased risk differentiation and reduced sample size of the risk classes. A reduction in the sample size results in increased estimation error in the average cost of equity for the risk groups. In any event, multiple risk variables are best analyzed in an econometric framework which we do in subsequent methodologies.

In summary, the pure play approach is a convenient, easy-to-apply technique to obtain a first approximation of the equity costs of subsidiaries. The estimates of these equity costs are only as good as the estimate of the average equity costs of the comparable risk groups. Based on our results and the application of a reasonableness criterion, we have more confidence in the DCF model estimates than the CAPM estimates.

Estimates of Subsidiary Equity Costs Using an Econometric Model Based on Real Determinants of Risk

In this econometric approach we estimate a cross-sectional relationship between the cost of equity for a sample of traded firms and the real or fundamental determinants of these costs. The model specifications are as described by Models M1 and M2. We chose a sample of 79 operating utilities that were traded in the NYSE and for which Value Line forecast data were available. Appendix Table A-3 lists the companies in the sample.

As described in Chapter 3, in Model M1 we specify

$$k_i = a_0 + a_1(\text{business risk})_i + a_2(\text{EQR})_i + a_3(\text{AFUDC/NI})_i + a_4(\text{FT})_i + a_5(\Delta\text{ROE})_i + a_6(\text{NUK})_i + U_i \tag{4-1}$$

and in Model M2 we specify

$$k_i = a_0 + a_1(\text{equity risk})_i + a_2(\text{AFUDC/NI})_i + a_3(\text{FT})_i + a_4(\Delta\text{ROE})_i + a_5(\text{NUK})_i + U_i \tag{4-2}$$

In both models $\hat{a}_0$ should approximate the risk-free rate.

We have four alternative measures of k_i--DCF k_i measures, using the constant and non-constant growth model and CAPM k_i measures using historic and ex-ante measures of market risk premium. We have two measures of business risk--standard deviation of ROI, measuring total business risk and accounting ROI beta, measuring systematic business risk--resulting in eight regression estimates for Model M1. We also have two measures of equity risk--standard deviation of ROE, measuring total equity risk and accounting ROE beta, measuring systematic equity risk--resulting in eight regression estimates for Model M2. In order to decide which specification and which measurement technique is most appropriate we use the following criteria.

1. Goodness of fit, as measured by the coefficient of determination, R^2.
2. Significance and signs of the regression coefficient.
3. The closeness in the agreement between the intercept term a_0 and the risk-free rate measured as the yield on long-term Government bonds.

Based on these criteria, the recommended specification is Model M2 with k_i measured as the constant growth DCF k, and equity risk measured as the accounting ROE beta, BROE. In Table 4-11 we show the regression results for the recommended specification and measurement technique. The regression results from all other specifications and measurement techniques are presented in Appendix Tables A-4 to A-18.

From the regression results presented in Table 4-11 we observe the following:

1. The intercept term is highly significant and consistently higher than the risk-free rate, with the same trend over time.
2. The coefficient of equity risk, measured as the accounting ROE beta, is significant in each year and has the right sign.
3. The coefficient of AFUDC/NI has the right sign and is significant in each year except 1978.
4. The coefficient of the dummy variable, FT, has the right sign in four out of five years but is not significant in any year.
5. The coefficient of ΔROE which proxies for regulatory lag is not significantly different from zero in any of the years.
6. The coefficient of NUK, measured as the percentage of total generation from nuclear plants, is negative in all years and significant in 1978, 1979 and 1981. This finding is contrary to our expectations. Given the prevailing uncertainty regarding the whole question of nuclear power we would expect a positive relationship between cost of equity and the proportion of generation from nuclear plants, at least since the Three Mile Island accident in

Table 4-11
Regression Results Based on Determinants-of-Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_1)_i = a_0 + a_1(\text{BROE})_i + a_2(\text{AFUDC/NI})_i + a_3(\text{FT})_i + a_4(\Delta\text{ROE})_i + a_5(\text{NUK})_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1190 (46.91)	0.0088 (3.37)	0.0146 (2.24)	0.0011 (0.42)	-0.0819 (-1.61)	-0.0098 (-1.80)	0.2254	0.0095	0.0787
1978	0.1363 (46.34)	0.0104 (3.68)	0.0100 (1.31)	0.0031 (1.04)	-0.0614 (-0.91)	-0.0144 (-2.31)	0.2395	0.0107	0.0891
1979	0.1471 (54.05)	0.0121 (4.04)	0.0154 (2.16)	0.0050 (1.63)	0.0244 (0.33)	-0.0176 (-2.57)	0.2895	0.0107	0.1018
1980	0.1590 (42.73)	0.0127 (3.70)	0.0147 (1.90)	-0.0004 (-0.08)	0.0470 (0.55)	-0.0055 (-0.62)	0.1315	0.0140	0.1200
1981	0.1557 (54.39)	0.0107 (4.07)	0.0208 (3.75)	0.0005 (0.13)	-0.0136 (-0.20)	-0.0162 (-2.12)	0.2529	0.0116	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_1 is the constant growth DCF cost of equity capital.

1979. The anamolous result could arise because of the problem in defining and measuring this variable. As measured in this analysis, the variable does not pick up the impact of nuclear power plants under construction. A utility could have a small percentage of nuclear power generation and yet have a high level of nuclear risk if it has a nuclear plant under construction.

7. The R^2 values are not particularly high, the highest value being 28.95 percent in 1979. The standard error of estimation ranges from a low of 0.95 percent to a high of 1.4 percent.

In Tables 4-12 to 4-14 we show the cost of equity estimates of the chosen subsidiaries based on the recommended model. We could estimate the subsidiary equity costs only for the years 1979 to 1981, because data on the ROE series, used to estimate accounting beta, BROE, was not available for the early years.

In comparing these estimates with the pure play estimates we note that there is a reasonably close agreement, with the pure play estimates lying within the econometric model estimates $\pm$ 2 standard errors. However, the standard errors of the estimate are quite high.

Estimates of Subsidiary Equity Costs Using an Econometric Model Based on the Gordon Valuation Equation

These estimates are based on Model M3 described in Chapter 3. The model, based on the Gordon valuation equation, specifies

$$\begin{aligned}(P/B)_i &= a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i \\ &\quad + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i \qquad (4\text{-}3)\end{aligned}$$

Table 4-12
Subsidiary Equity Costs Based on
Determinants-of-Equity-Cost Model

	Subsidiaries				Parent
Year	Alabama Power	Georgia Power	Gulf Power	Mississippi Power	Southern Co.
1979	14.82%	15.19%	13.38%	14.10%	14.92%
1980	15.96	16.12	14.73	14.64	16.19
1981	15.84	16.02	14.54	14.66	15.94

Table 4-13
Subsidiary Equity Costs Based on
Determinants-of-Equity-Cost Model

	Subsidiaries					Parent
Year	Appalachian Power	Columbus & Southern Ohio	Indiana & Michigan Power	Kentucky Power	Ohio Power	American Electric Power
1979	12.88%	15.06%	13.74%	13.72%	14.58%	14.14%
1980	13.88	16.21	15.39	14.75	15.09	15.34
1981	14.07	16.09	15.63	15.13	14.98	15.16

Table 4-14
Subsidiary Equity Costs Based on
Determinants-of-Equity-Cost Model

	Subsidiaries				Parent
Year	Arkansas Power	Louisiana Power & Light	New Orleans Public Service	Mississippi Power & Light	Middle South Utilities
1979	15.38%	15.13%	13.66%	14.44%	15.16%
1980	17.13	16.44	15.24	15.63	17.10
1981	16.19	16.62	14.75	15.62	16.05

We used three alternative measures for expected return on book equity, EROE--the normalized return on equity, NROE; the predicted return on equity, PROE, and the instrumental variable return on equity, IVROE. We tried two measures of equity risk--the total equity risk, SROE, measured as the standard deviation of historical returns and the systematic equity risk, BROE, measured as the accounting ROE beta. Thus the model provides six regression equation estimates in each year. Again, the choice of the most appropriate measurement technique is determined by the R^2 values and the signs and significance of the regression coefficients. Based on these criteria we recommend the following measurement techniques:

1. The expected ROE to be measured as the normalized return on book equity, NROE.
2. The equity risk to be measured as the accounting ROE beta, BROE.

These recommendations are consistent with those for the determinants-of-equity-risk model in which the best measure of the dependent variable k_i was the constant growth DCF k_i with dividend growth based on NROE and the best measure of equity risk was BROE. Table 4-15 shows the regression results for the recommended specification and variable measurement. In Appendix Tables A-19 to A-23 we present the regression results for all other variable measurement techniques.

Based on the regression results in Table 4-15, we can make the following observations:

Table 4-15
Regression Results Based on Determinants the Gordon Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROI)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE
1977	0.3281 (2.23)	6.326 (5.32)	-0.0703 (-2.42)	-0.1511 (-2.11)	-0.0311 (-1.13)	-0.9751 (-1.40)	0.1473 (2.49)	0.5123	0.1032
1978	0.2217 (1.99)	5.630 (6.29)	-0.0652 (-2.56)	-0.0798 (-1.20)	-0.0045 (-0.17)	-0.4352 (-0.69)	0.1087 (2.05)	0.4195	0.0936
1979	0.2760 (3.01)	4.552 (6.56)	-0.0778 (-3.63)	-0.0672 (-1.40)	-0.0138 (-0.66)	-1.402 (-2.56)	-0.0076 (-0.16)	0.5330	0.0723
1980	0.2395 (1.92)	4.370 (4.65)	-0.0440 (-1.76)	-0.0741 (-1.44)	0.0178 (0.58)	-0.5235 (-0.87)	-0.0654 (-1.05)	0.3067	0.0931
1981	0.0740 (0.61)	5.903 (6.60)	-0.0533 (-2.45)	-0.0814 (-2.07)	-0.0226 (-0.78)	-0.1756 (-0.33)	0.0202 (0.36)	0.4585	0.0816

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the normalized rate of return, NROE.

(3) Equity risk measured as accounting ROE beta, BROE.

1. The coefficient of expected ROE is positive and significant, at a 5 percent significance level, in every year. All else held constant the higher the EROE, the higher the P/B ratio and lower the cost of equity.
2. The coefficient of equity risk, BROE, is negative in all the years and significant, at a 5 percent significance level, in four out of the five years. The higher the equity risk, the lower the P/B ratio and higher the cost of equity.
3. The coefficient of AFUDC/NI is negative in all the years and significant in two out of five years. As expected this coefficient is negatively correlated with the P/B ratio and positively correlated with the cost of equity.
4. The coefficient of the flow-through dummy variable, FT, has the expected negative sign in four out of five years but is not significant in any year.
5. The coefficient of ΔROE has the expected negative sign in every year but is significant, at a 5 percent significance level, in only one year.
6. The coefficient of NUK is significant in 1977 and 1978 with an inverse relationship to equity cost. In the remaining years it is insignificant. The inverse relationship in the early years may not be unreasonable. However, our expectation of a positive relationship to equity cost since the Three Mile Island accident is not confirmed by our results.
7. The R^2 values are quite high ranging from 30.7 percent in 1980 to 53.3 percent in 1979. The standard error of estimation ranges from 0.07 to 0.10.

From the regression equations in Table 4-15 we estimate the equity cost of the subsidiary and parent firms by setting P/B = 1.0 and solving for EROE. As developed in Chapter 3, the P/B ratio is 1.0 when the expected return on book equity is equal to the cost of equity. We present the cost of equity estimates in Tables 4-16 to 4-18.

The cost of equity estimates using the Gordon model are in reasonably close agreement with those using the pure play approach and the determinants-of-equity-cost model in the years 1979 and 1981. However, the Gordon model estimates in 1980 are consistently higher than the estimates by the other two methods. The regression equation for 1980 also has the lowest R^2 value. Beyond speculating that the errors in variable problem was more severe in 1980, we have no explanation for this finding.

Testing for the Validity of the Estimate. Since the Gordon model in the P/B form allows for the estimation of both, the cost of equity and the market value of the subsidiaries we can test for the validity of the estimates under the assumption that Value Additivity holds. The validation test involves the following:

1. Estimating the cost of equity for the subsidiaries by setting P/B = 1.0 and solving for EROE.
2. Estimating the price-book ratio $(\widehat{P/B})$ for the subsidiaries from the regression equations.
3. Estimating the market value of the subsidiaries knowing the subsidiary book value of common equity, B.

$$\hat{V} = (\widehat{P/B})B \qquad (4\text{-}4)$$

Table 4-16
Subsidiary Equity Costs Based on the Gordon Valuation Equation Model

	Subsidiaries				Parent
Year	Alabama Power	Georgia Power	Gulf Power	Mississippi Power	Southern Co.
1979	15.34%	16.44%	13.67%	14.53%	15.79%
1980	18.13	18.01	16.39	16.70	18.02
1981	15.77	16.02	14.71	14.95	15.94

Table 4-17
Subsidiary Equity Costs Based on the Gordon Valuation Equation Model

	Subsidiaries					Parent
Year	Appalachian Power	Columbus & Southern Ohio	Indiana & Michigan Power	Kentucky Power	Ohio Power	American Electric Power
1979	12.81%	15.94%	15.69%	14.56%	15.16%	15.04%
1980	15.94	17.80	18.45	16.80	16.86	17.29
1981	14.28	15.96	15.66	16.23	15.13	15.34

Table 4-18
Subsidiary Equity Costs Based on the Gordon Valuation Equation Model

	Subsidiaries				Parent
Year	Arkansas Power	Louisiana Power & Light	New Orleans Public Service	Mississippi Power & Light	Middle South Utilities
1979	16.35%	15.00%	13.35%	14.44%	15.89%
1980	19.33	18.21	16.69	17.30	19.30
1981	16.48	16.32	15.03	15.68	16.24

4. Testing for the equality

$$V_p = \Sigma \hat{V}_i \tag{4-5}$$

where

V_p = observed market value of the parent

$\hat{V}_i$ = estimated market value of subsidiary i

5. Testing for the equality

$$k_p = \Sigma w_i k_i \tag{4-6}$$

where

k_p = parent's cost of equity estimated from capital market data using a cost of capital model

k_i = subsidiary cost of equity estimated from the regression equations

w_i = market value of equity fraction, V_i/V_p

If the equalities represented by Equations (4-5) and (4-6) hold, then the validity of the estimates of subsidiary equity costs would be established. One problem that arises in implementing this analysis is that Step 2, which involves estimating the $(\hat{P/B})$ for subsidiaries, cannot be carried out using the recommended specification and variable measures. To predict $(\hat{P/B})$, we need to be able to measure all the independent variables for the subsidiaries. Expected ROE measured as normalized ROE, cannot be measured for subsidiaries since this measure involves capital market data which are not available for subsidiaries. Specifically

$$\text{NROE} = \frac{\text{DPS}_0}{(\text{POR})(\text{BVS}_0)} \tag{4-7}$$

and we do not have data on dividends paid, DPS_0, and payout ratio, POR. To circumvent this problem we estimate the $(\widehat{P/B})$ for subsidiaries, using regression equations, shown in Appendix Table A-20, in which the expected ROE is measured as a projected return on equity, PROE. This measure of expected ROE is readily estimated for subsidiaries since it depends only on time series data of past returns on book equity.

In Tables 4-19 to 4-21 we show the estimates of the P/B ratios and market values of equity for the subsidiaries in the years 1979-1981. In Table 4-22 we compare the sum of the estimated market values of the subsidiaries to the observed market value of the parent. The table also shows a comparison between the book value of equity of the parent and the sum of the book values of the subsidiary firms.

From Table 4-22 we see that

1. For Middle South Utilities the book value of the parent's common equity is significantly higher than the sum of the book values of its four subsidiaries. This implies that Middle South Utilities has other holdings, in addition to these subsidiaries. This makes the comparison of the parent market value and the sum of the estimated market value of these four subsidiaries invalid. The Value Additivity test is meaningful only if all the assets of the parent company are included in the analysis.
2. If Middle South Utilities is excluded then a two-tailed t-test carried out for the other two parent companies over the period 1979-1981 fails to reject at a significance level of 1.0 percent, the null hypothesis that the mean difference between market value

Table 4-19
Estimates of the P/B Ratios and Equity Market Values of the Subsidiaries of Southern Company, 1979-1981
(Dollars in Millions)

Company	1979			1980			1981		
	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$
Alabama Power	0.6147	$1,022.07	$ 628.27	0.5757	$1,210.48	$ 696.87	0.5459	$1,229.53	$ 671.20
Georgia Power	0.7230	1,209.76	744.52	0.7031	1,312.68	922.94	0.7597	1,455.54	1,105.77
Gulf Power	0.7449	171.99	128.12	0.6099	203.72	124.25	0.6299	220.35	138.80
Mississippi Power	0.7194	147.83	105.68	0.6444	149.59	96.40	0.7366	167.43	123.33
		ΣV_i =	$1,606.59		ΣV_i =	$1,840.46		ΣV_i =	$2,039.10

Table 4-20
Estimates of the P/B Ratios and Equity
Market Values of the Subsidiaries of
American Electric Power, 1979-1981
(Dollars in Millions)

Company	1979			1980			1981		
	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$
Appalachian Power	0.7781	$696.05	$ 541.60	0.6789	$780.69	$ 530.01	0.7313	$830.70	$ 607.49
Columbus & Southern Ohio	0.6932	430.86	298.67	0.6221	463.74	288.49	0.6605	505.69	334.01
Indiana & Michigan Power	0.6982	724.69	505.98	0.5854	761.22	445.62	0.6348	829.00	526.25
Kentucky Power	0.7564	144.30	109.15	0.7106	143.19	101.68	0.7417	149.51	110.89
Ohio Power	0.7613	851.48	648.22	0.7226	861.93	622.83	0.7683	928.74	713.55
		ΣV_i =	$2,103.62		ΣV_i =	$1,988.63		ΣV_i =	$2,292.19

Table 4-21
Estimates of the P/B Ratios and Equity
Market Values of the Subsidiaries of
Middle South Utilities, 1979-1981
(Dollars in Millions)

	1979			1980			1981		
Company	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$	$\widehat{P/B}$	B	$\hat{V}$
Arkansas Power	0.7207	$518.62	$373.77	0.5912	$517.59	$306.00	0.6511	$594.64	$ 387.17
Louisiana Power & Light	0.7548	480.43	362.63	0.6801	555.49	377.79	0.7591	607.28	460.99
New Orleans Public Service	0.7887	78.67	62.05	0.6737	72.10	48.57	0.7175	69.31	49.73
Mississippi Power & Light	0.8154	169.81	138.46	0.8297	179.41	148.86	0.9033	186.02	168.03
		ΣV_i =	$936.91		ΣV_i =	$881.22		ΣV_i =	$1,065.92

Table 4-22
Comparison of Subsidiary and Parent
Book Values and Market Values
of Equity, 1979-1981
(Dollars in Millions)

Year	Company	Book Value of Equity		Market Value of Equity	
		Parent	ΣSubsidiaries	Parent	ΣSubsidiaries
1979	Southern Company	$2,499.42	$2,551.65	$1,710.60	$1,606.59
	American Electric Power	2,586.62	2,847.38	2,168.88	2,103.62
	Middle South Utilities	1,659.02	1,247.53	1,141.73	936.91
1980	Southern Company	$2,834.74	$2,876.47	$2,066.53	$1,840.46
	American Electric Power	3,095.35	3,010.77	2,478.76	1,988.63
	Middle South Utilities	1,898.94	1,324.59	1,234.50	881.22
1981	Southern Company	$3,122.91	$3,072.85	$2,291.59	$2,039.10
	American Electric Power	3,321.60	3,243.64	2,618.75	2,292.19
	Middle South Utilities	2,183.27	1,457.25	1,562.79	1,065.92

of the parent and the sum of the market values of the subsidiaries is significantly different from zero.

3. Having established that for Southern Company and American Electric Power, the market value of equity of the parent, V_p, is not significantly different from the sum of the market values of their subsidiaries, ΣV_i, we can calculate the market value fraction of the subsidiaries as $w_i = V_i/\Sigma V_i$. These market value weights can then be used to test for the equality between the parent cost of equity, k_p, and the weighted sum of the costs of equity of subsidiaries, $\Sigma w_i k_i$.

In Tables 4-23 and 4-24 we show the computations of the market value fractions of the subsidiaries and the weighted sums of the subsidiary equity costs. In Table 4-25 we compare these weighted sums with the costs of equity of the parent companies, independently estimated from market models of cost of capital. A two-tailed t-test fails to reject, at a 5 percent significance level, the hypothesis that $k_p = \Sigma w_i k_i$.

In summary we draw the following conclusions regarding the econometric approach based on the Gordon valuation equation:

1. The model estimates are reasonable with regard to goodness of fit and the signs/significance of the coefficients. However the coefficients are not very stable over time. The estimates of equity costs in 1980 appear to be consistently higher than by any other approach.

Table 4-23
Estimates of the Weighted Sum of Equity Costs of the Subsidiaries of Southern Company, 1979-1981
(Dollars in Millions)

Year	Company	Market Value of Equity, v_i	Market Value Fraction, w_i	Equity Cost, k_i		w_ik_i
1979	Alabama Power	$ 628.27	0.3911	15.34%		6.00%
	Georgia Power	744.52	0.4634	16.44		7.62
	Gulf Power	128.12	0.0797	13.67		1.09
	Mississippi Power	105.68	0.0658	14.53		0.96
					Σw_ik_i =	15.67%
1980	Alabama Power	$ 696.87	0.3786	18.13%		6.86%
	Georgia Power	922.94	0.5015	18.01		9.03
	Gulf Power	124.25	0.0675	16.39		1.11
	Mississippi Power	96.40	0.0524	16.70		0.88
					Σw_ik_i =	17.88%
1981	Alabama Power	$ 671.20	0.3292	15.77%		5.19%
	Georgia Power	1,105.77	0.5422	16.02		8.69
	Gulf Power	138.80	0.0681	14.71		1.00
	Mississippi Power	123.33	0.0605	14.95		0.90
					Σw_ik_i =	15.78%

Table 4-24
Estimates of the Weighted Sum of Equity Costs of the Subsidiaries of American Electric Power, 1979-1981
(Dollars in Millions)

Year	Company	Market Value of Equity, v_i	Market Value Fraction, w_i	Equity Cost, k_i	w_ik_i
1979	Appalachian Power	\$541.60	0.2575	12.81%	3.30%
	Columbus & Southern Ohio	298.67	0.1420	15.94	2.26
	Indiana & Michigan Power	505.98	0.2505	15.69	3.93
	Kentucky Power	109.15	0.0519	14.56	0.76
	Ohio Power	648.22	0.3081	15.16	4.67
				Σw_ik_i =	14.92%
1980	Appalachian Power	\$530.01	0.2665	15.94%	4.25%
	Columbus & Southern Ohio	288.49	0.1451	17.80	2.58
	Indiana & Michigan Power	445.62	0.2241	18.45	4.13
	Kentucky Power	101.68	0.0511	16.80	0.86
	Ohio Power	622.83	0.3132	16.86	5.28
				Σw_ik_i =	17.10%
1981	Appalachian Power	\$607.49	0.2650	14.28%	3.78%
	Columbus & Southern Ohio	334.01	0.1457	15.96	2.33
	Indiana & Michigan Power	526.25	0.2296	15.66	3.60
	Kentucky Power	110.89	0.0484	16.23	0.79
	Ohio Power	713.55	0.3113	15.13	4.71
				Σw_ik_i =	15.21%

Table 4-25
Comparison of Cost of Equity of Parent with Weighted Sum of Costs of Equity of Subsidiaries

Year	Company	Cost of Equity Parent, k_p	Cost of Equity Subsidiaries, $\Sigma w_i k_i$
1979	Southern Company	15.08%	15.67%
	American Electric Power	13.79	14.92
1980	Southern Company	14.99%	17.88%
	American Electric Power	14.87	17.10
1981	Southern Company	15.30%	15.78%
	American Electric Power	15.21	15.29

Note: The parent cost of equity, k_p, is the constant growth DCF estimate.

2. The model allows for the estimation of both the market value of and cost of equity of the subsidiaries. The estimates passed the validity tests made under the assumption that the Value Additivity principle holds. The sum of the estimated values of the subsidiaries was not significantly different from the observed market value of the parent and the weighted sum of the equity costs of the subsidiaries was not significantly different from the market model estimates of the parent's equity costs.

Estimates of Subsidiary Equity Costs Using an Econometric Model Based on the CAPM

Under the subsidiary approach, the third econometric model that we used is based on the CAPM and was developed by Litzenberger and Rao (1971). Starting with CAPM equation this model (Model M5) specifies

$$(P/B)_i = \alpha_1(EROE)_i + \alpha_2(\sigma_{ROE})_i + \alpha_3[\frac{g_i(ROE_i - k)}{k(1 + k)}]_i + U_i \qquad (4\text{-}8)$$

where

$\hat{\alpha}_1 = \frac{1}{R_F}$ = measure of marginal rate of time preference

$\hat{\alpha}_2 = \frac{-br_{im}}{R_F}$ = measure of risk aversion

$\hat{\alpha}_3 = T$ = measure of futures years of investment's earnings in excess of the cost of capital

The cost of equity capital is then measured from the regression equations as

$$\begin{aligned} k_i &= R_F + (br_{im})\sigma_{ROE_i} \\ &= \frac{1}{\hat{\alpha}_1} + \frac{\hat{\alpha}_2}{\hat{\alpha}_1}\sigma_{ROE_i} \qquad (4\text{-}9) \end{aligned}$$

In Table 4-26 we show the regression results obtained with an exact replication of the Litzenberger-Rao model using their measurement techniques which consist of measuring expected ROE as an average of past ROE and expected σ_{ROE} as standard deviation of past returns. From the regression results in Table 4-26 we see that

1. The coefficient of EROE is positive, as expected, and significant in all years at a significance level of 5 percent.
2. The reciprocal of $\hat{\alpha}_1$ consistently overestimates the risk-free rate by as much as 75 percent.

Table 4-26
Regression Results Based on a Replication of the Litzenberger-Rao Model, 1977-1981

Model: M5

Regression: $(P/B)_i = \alpha_0 + \alpha_1(EROE)_i + \alpha_2(\sigma_{ROE})_i + \alpha_3[\frac{g_i(EROE_i - k)}{k(1 + k)}]_i + U_i$

Sample: 79 electric utilities

Year	α_0	α_1	α_2	α_3	R^2	SEE	$R_F = 1/\alpha_1$	R_F
1977	0.0448 (0.24)	8.582 (5.11)	-2.241 (-0.97)	-1.065 (-0.98)	0.5195	0.1045	0.1165	0.0787
1978	0.0646 (0.32)	7.084 (4.17)	-2.330 (-1.36)	-1.058 (-0.69)	0.5119	0.0876	0.1412	0.0891
1979	0.1134 (1.15)	5.597 (7.35)	0.3176 (0.22)	-0.4598 (-0.63)	0.5193	0.0748	0.1787	0.1018
1980	0.1454 (1.46)	4.795 (6.18)	0.8242 (3.13)	-0.5145 (-0.88)	0.3458	0.0923	0.2086	0.1200
1981	0.1385 (1.59)	5.214 (7.50)	1.123 (0.76)	-0.1715 (-0.39)	0.4310	0.0853	0.1918	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

3. The coefficient $\hat{\alpha}_2$, which is a measure of investor risk aversion, has the hypothesized negative sign in only two out of five years and is not significant in any year.
4. The coefficient $\hat{\alpha}_3$, which measures the number of years of future discounted earnings growth implicit in the market values. For utilities under fair regulation there would be no opportunity for future investment to earn more than its cost of capital. Under fair regulation the hypothesis should be $\alpha_3 = T = 0$. The α_3 coefficients were in fact not significantly different from zero in any of the years.

Given the excessive overestimation of the risk-free rate as measured by $1/\hat{\alpha}_1$, we did not proceed with the estimation of subsidiary equity costs from these regression equations. Instead, we tried to improve the model estimation by modifying the Litzenberger-Rao specification and measurement techniques, as described in Chapter 3. In the modified specification described by Model M6,

$$(P/B)_i = \alpha_1 (EROE)_i + \alpha_2 (r_{im}\sigma_{ROE})_i + \alpha_3 \left[\frac{g_i(ROE_i - k)}{k(1 + k)}\right]_i + U_i \qquad (4\text{-}8)$$

The main differences between the modified and the original model are that in the modified version we:

1. Incorporate the correlation coefficient, r_{im}, as the variable rather than as a constant coefficient for the sample.
2. Proxy $r_{im}\sigma_{ROE}$ as accounting ROE beta.
3. Measure EROE not as historical returns but alternatively as normalized ROE, projected ROE and instrumental variable ROE.

4. Measure g_i, not as historical growth in book value but as Value Line's 5-year projected growth.

Table 4-27 shows the regression results for the modified specification with the independent variable measures that produced the "best" results in terms of goodness of fit and signs/significance of coefficients. Comparing the regression results from the original specification and the modified specification we note the following:

1. The coefficient $\hat{\alpha}_3$ is now negative in all the years and significant in four out of the five years. With the original specification this coefficient was not significant in any year and had the expected negative sign in only two years.
2. The reciprocal of $\hat{\alpha}_1$ is now closer to the risk-free rates but the differences are still too large to make this model viable for estimating equity capital costs.

Thus, although there is some improvement with the modified specification and measurements this model will not produce reasonable estimates of the cost of equity of the subsidiaries. The main reason for the failure of this model is that it recognizes the variability in ROE as the only measure of a firm's risk. At least in the case of utilities, there are other sources of risk like the quality of earnings or returns, as measured by the AFUDC/NI ratio, regulatory risk, etc., which are not captured by ROE variability. For the rest of the analysis we will not pursue the Litzenberger-Rao model.

Table 4-27
Regression Results Based on the Modified
Litzenberger-Rao Model, 1977-1981

Model: M6

Regression: $(P/B)_i = \alpha_0 + \alpha_1(EROE)_i + \alpha_2(BROE)_i + \alpha_3\left[\frac{g_i(EROE_i - k)}{k(1 + k)}\right]_i + U_i$

Sample: 79 electric utilities

Year	α_0	α_1	α_2	α_3	R^2	SEE	$R_F = 1/\alpha_1$	R_F
1977	-0.0657 (-0.27)	9.297 (4.39)	-0.0561 (-1.98)	-1.221 (-0.75)	0.4775	0.1089	0.1076	0.0787
1978	-0.0657 (-0.41)	7.687 (6.14)	-0.0439 (-1.91)	-1.985 (-1.76)	0.4422	0.0934	0.1301	0.0987
1979	0.1169 (1.18)	5.437 (7.28)	-0.0529 (-2.63)	-0.1965 (-0.29)	0.4939	0.0768	0.1839	0.1018
1980	0.0894 (0.74)	5.158 (5.68)	-0.0333 (-1.44)	-0.4123 (-0.51)	0.3292	0.0934	0.1939	0.1200
1981	0.0791 (0.68)	5.706 (6.78)	-0.0512 (-2.34)	0.6909 (0.82)	0.4619	0.0830	0.1753	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

Estimates of Subsidiary Equity Costs Using an Econometric Model Based on the Theory of the Firm

This model (Model M7) relates systematic risk of a firm to its factor proportions and monopoly power. In its simplified form,

$$\beta_i = a_0 + a_1(L/K)_i + a_2(MP)_i + U_i \tag{4-11}$$

where

β = firm's unlevered beta

L/K = firm's labor to capital ratio proxied for utilities as (average number of employees)/(net generating capacity)

MP = monopoly power proxied for utilities as (sales - operating expenses)/(sales)

In Table 4-28 we show the regression results produced by Model M7, for the years 1977-1980. Data for the (L/K) ratio were not available for all the utilities in 1981. From the regression results we observe that

1. The coefficient a_1 is insignificant in all the years.
2. The coefficient a_2 has the expected negative sign but is insignificant in all the years.
3. The R^2 values are extremely low.

These results point to severe errors in measurement of the variables. We used proxy measures for both the factor proportions and monopoly power, and it appears that these proxies are not appropriate measures of the independent variables. Thus, although this approach has a rigorous theoretical development, problems in measurement of the variables make its implementation difficult. More work needs to be done to obtain more accurate measures of the explanatory variables.

Table 4-28
Regression Results Based on the
Theory of the Firm Model

Model: M7

Regression: $\beta_i = a_0 + a_1(L/K)_i + a_2(MP)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	R^2	SEE
1977	0.5054 (13.63)	-0.0183 (-0.82)	-0.0430 (-1.35)	0.0442	0.1084
1978	0.4493 (13.13)	-0.0169 (-0.80)	-0.0258 (-0.83)	0.0271	0.1044
1979	0.4202 (12.79)	0.0036 (0.21)	-0.0002 (-0.00)	0.0006	0.1027
1980	0.2104 (10.34)	0.0111 (0.77)	-0.0022 (-0.12)	0.0082	0.0591

Note: Figures in parentheses are t values.

In summarizing the estimations of the cost of equity of electric utility subsidiaries by the various methodologies developed, we draw the following conclusions:

1. The pure play approach is easy to implement but does not provide any statistical properties of the estimates. It is a convenient way of obtaining a good first approximation of subsidiary equity costs. In the estimation of capital costs for the comparable risk groups we have more confidence in the DCF estimates than in the CAPM estimates.

2. The determinants-of-equity-cost econometric model produces estimates not significantly different from the pure play estimates. The pure play estimates are within ± 2 standard errors of the econometric estimates. However, the standard error is quite high and the R^2 values are low.
3. The econometric model based on the Gordon Valuation equation provides estimates of the cost of equity and market value of subsidiaries. This permits a test of the validity of the estimates under the assumption of Value Additivity. For a small sample of two parent companies over three years we fail to reject the hypothesis that the observed parent value is equal to the sum of the estimated subsidiary values and that the parent equity cost is the weighted sum of the subsidiary equity costs. The one problem with this model is in the stability of the coefficients over time.
4. The econometric model based on the CAPM, as developed by Litzenberger and Rao, has the same potential as the Gordon model for estimating subsidiary equity costs and market value of equity. However, this model admits the ROE variability as the only measure of risk. The model estimates and the equity costs estimates from this approach are unreasonable.
5. The econometric approach based on the theory of the firm has severe measurement problems which make its implementation difficult. The potential of this approach will be realized only if we can accurately factor proportion and monopoly power.

In the following sections we will estimate the equity costs for Western Electric and Telephone subsidiaries, using only the pure play approach and the Gordon valuation equation model.

Estimation of Capital Costs of Western Electric

To estimate the equity capital cost of Western Electric we applied the pure play approach and the econometric approach based on the Gordon valuation equation.

Estimates of Western Electric Cost of Equity Using the Pure Play Approach

As discussed in Chapter 3 the comparable risk group for Western Electric consists of 26 of the largest manufacturing firms in Fortune 500, with high bond rating (AA or AAA). In Appendix Table A-24 we list the firms in the comparable risk group. In Table 4-29 we show the equity cost estimates for Western Electric in the years 1977-1981. The cost of equity of Western Electric is estimated as the average of the equity cost of the Fortune 26 group of companies. The equity cost of the individual firms in the risk group is estimated as the constant growth DCF cost of equity.

Table 4-29
Western Electric's Cost of Equity Capital
Based on the Pure Play Approach

Year	Cost of Equity Capital, k
1977	14.86%
1978	15.67
1979	16.09
1980	15.48
1981	15.60

Note: Cost of equity for the risk group is based on the constant growth DCF model.

Estimates of Western Electric Cost of Equity Based on the Gordon Valuation Equation

These estimates are based on Model M4 described in Chapter 3. The model specifies

$$(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + U_i \qquad (4\text{-}12)$$

Based on our findings on the model estimates for electric utilities, we measure the expected return on equity, EROE, as the normalized return of equity, NROE and equity risk as the accounting ROE beta, BROE. In Table 4-30 we present the regression equations for the years 1977-1981. From the regression results we see that

1. The coefficient of EROE has the expected positive sign in each year and is significant in all the years at a 5 percent significance level.
2. The coefficient of BROE has the expected negative sign in each year and is significant in three out of the five years, at a 5 percent significance level.
3. The R^2 values range from 55 percent to 65 percent.

From these regression equations we can estimate the cost of equity for Western Electric by setting P/B = 1.0 and solving for EROE. In Table 4-31 we show these estimates for the years 1979-1981.

To estimate the market value of Western Electric's equity we estimate its $\widehat{P/B}$ from the regression equations with expected ROE measured as projected ROE. Western Electric's equity market value is then $(\widehat{P/B})B$. In Table 4-32 we show the regression equations used to estimate $\widehat{P/B}$ along with estimations of Western Electric's $\widehat{P/B}$ and market value of equity $\hat{V}$ for the years 1979 to 1981.

Table 4-30
Regression Results Based on the Gordon Model, 1977-1981

Model: M4

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + U_i$

Sample: Fortune 26 group of firms

Year	a_0	a_1	a_2	R^2	SEE
1977	-0.0755 (-0.18)	12.05 (5.36)	-0.2815 (-3.35)	0.6543	0.4238
1978	-0.9445 (-1.83)	15.79 (5.67)	-0.2087 (-2.09)	0.6248	0.4592
1979	-0.9638 (-2.44)	13.98 (6.55)	-0.0246 (-0.31)	0.6437	0.3254
1980	-1.0150 (-2.77)	13.95 (6.85)	-0.2058 (2.21)	0.6523	0.3969
1981	-0.4832 (-1.26)	10.40 (5.67)	-0.0606 (0.19)	0.5489	0.3597

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the normalized rate of return, NROE.

(3) Equity risk measured as accounting ROE beta, BROE.

Table 4-31
Western Electric's Equity Cost Based on the Gordon Valuation Equation Model

Year	Cost of Equity
1979	14.82%
1980	16.89
1981	15.24

Table 4-32
Estimate of Western Electric's Equity Market Value Based on the Gordon Model, 1979-1981

Model: M4

Regression: $\widehat{(P/B)}_i = a_0 + a_1(\text{EROE})_i + a_2(\text{equity risk})_i + U_i$

Sample: Fortune 26 group of firms

Year	a_0	a_1	a_2	R^2	SEE	$\widehat{P/B}$	B	$\hat{V}$
1979	-1.0480 (-2.13)	14.93 (5.54)	-0.1270 (-0.31)	0.6027	0.3583	0.83	$4,021.6	$3,337.9
1980	-1.4000 (-2.42)	16.28 (4.97)	-0.0528 (0.49)	0.5279	0.4821	1.01	4,449.3	4,486.9
1981	-0.9633 (-2.53)	13.37 (5.78)	-0.1506 (1.92)	0.5938	0.3559	0.93	4,991.2	4,641.8

Notes: (1) Figures in parentheses are t values.

(2) Expected ROE measured as projected rate of return, PROE.

(3) All dollar values in millions.

Estimation of Capital Costs of Telephone Subsidiaries

As in the case of Western Electric we estimated the equity costs of AT&T subsidiaries using the pure play approach and the Gordon Valuation equation model.

Estimates of the Equity Costs of Telephone Subsidiaries Using the Pure Play Approach

The comparable risk group that we chose consists of the nine telephone companies for which capital market data were available. In Appendix Table A-25 we list the firms in the comparable risk groups. In Table 4-33 we present the cost of equity for the subsidiaries equal to the average of the DCF costs of equity of the firms in the risk group, for the years 1977-1981.

Table 4-33
Costs of Equity of Telephone Subsidiaries
Based on the Pure Play Approach,
1977-1981

Year	Cost of Equity
1977	12.78%
1978	14.60
1979	15.33
1980	16.09
1981	14.97

Estimates of the Cost of Equity of Telephone Subsidiaries Based on the Gordon Valuation Equation

We used the same model specifications and measurement techniques as was used to estimate the cost of equity of Western Electric.

$$(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + U_i$$

with EROE measured as the normalized rate of return, NROE and equity risk measured as the accounting ROE beta.

Table 4-34 shows the regression results for the years 1977-1981. We observe that

1. The coefficient of EROE has the expected positive sign and is significant at a 5 percent significance level in all the years.
2. The coefficient of BROE has the expected negative sign in three out of five years and is significant in only one year.
3. The R^2 values are high, ranging from 57.7 to 83.3 percent.

In Table 4-35 we show the estimates of the equity costs for the subsidiaries of AT&T, calculated from these regression equations for the years 1979-1981.

In Table 4-36 we show the estimates of the P/B ratio and market value of equity, V_i, for the subsidiary firms in the years 1979-1981. As in the case of electric utilities and Western Electric, the P/B ratio estimates are obtained from the regression model specification in which the expected return on equity, EROE, is measured as the projected return on equity, PROE. Appendix Table A-26 shows the regression results from this specification. In Table 4-37 we compare the sum of the market

Table 4-34
Regression Results Based on the Gordon Model, 1977-1981

Model: M4

Regression: $(P/B)_i = a_0 + a_1(\text{EROE})_i + a_2(\text{equity risk})_i + U_i$

Sample: 9 telephone companies

Year	a_0	a_1	a_2	R^2	SEE
1977	-0.0207 (-0.08)	8.4130 (4.16)	0.1212 (1.68)	0.7565	0.1024
1978	-0.0591 (-0.21)	7.5390 (3.95)	0.0105 (0.15)	0.7221	0.0969
1979	-0.2442 (-0.53)	8.9960 (2.82)	-0.0879 (-0.78)	0.5767	0.1407
1980	-0.0290 (-0.13)	7.2720 (4.79)	-0.1629 (-2.69)	0.8331	0.0734
1981	-1.2450 (-2.57)	16.2100 (5.06)	-0.0846 (0.93)	0.8279	0.1057

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the normalized rate of return, NROE.

(3) Equity risk measured as accounting ROE beta, BROE.

Table 4-35
Estimates of the Costs of Equity of Telephone Subsidiaries Based on the Gordon Model, 1979-1981

Company	Cost of Equity 1979	Cost of Equity 1980	Cost of Equity 1981
New England Telephone & Telegraph	14.76%	16.43%	14.43%
New York Telephone Company	14.80	16.50	14.44
New Jersey Bell	14.62	16.10	14.33
Pennsylvania Bell	14.50	15.72	14.23
Diamond State Telephone Company	14.53	15.90	14.28
Chesapeake & Potomac Telephone Co.	14.89	16.72	14.46
Chesapeake & Potomac of Maryland	14.56	15.68	14.20
Chesapeake & Potomac of Virginia	14.69	16.25	14.36
Chesapeake & Potomac of W. Virginia	13.95	14.25	13.87
Southern Bell	14.67	16.18	14.35
Ohio Bell	14.51	16.08	14.34
Michigan Bell	15.13	17.15	14.59
Indiana Bell	14.33	15.25	14.12
Wisconsin Telephone Company	15.03	17.13	14.57
Illinois Bell	14.48	15.67	14.25
Northwestern Bell	14.61	15.98	14.28
Southwestern Bell	14.36	15.43	14.17
Mountain States Telephone & Telegraph	14.02	14.62	13.98
Pacific Northwest Bell	14.40	15.62	14.21

Table 4-36
Estimates of the P/B Ratio and
Equity Market Value of Telephone
Subsidiaries, 1979-1981
(Dollars in Millions)

Company	1979			1980			1981		
	P/B	B	V	P/B	B	V	P/B	B	V
New England T&T	0.76	$1,989.7	$ 1,510.7	0.74	$2,061.1	$ 1,525.2	0.78	$2,445.7	$ 1,907.6
New York Telephone Co.	0.66	4,828.7	3,186.9	0.67	4,921.9	3,297.7	0.64	5,202.2	3,329.4
New Jersey Bell	0.81	1,895.8	1,535.6	0.78	1,955.5	1,525.3	0.81	2,136.3	1,730.4
Pennsylvania Bell	0.82	1,911.4	1,567.3	0.80	2,073.7	1,659.0	0.78	2,250.3	1,755.2
Diamond State Telephone Co.	0.85	153.6	130.6	0.82	165.5	135.7	0.83	169.9	141.0
C&P Telephone Co.	0.78	323.2	252.1	0.74	339.4	251.2	0.73	400.1	292.1
C&P of Maryland	0.84	957.0	803.9	0.81	969.9	785.6	0.74	1,099.9	813.9
C&P of Virginia	0.84	1,075.4	903.3	0.79	1,141.9	902.1	0.82	1,245.3	1,021.1
C&P of W. Virginia	0.87	354.2	315.2	0.91	386.8	352.0	0.80	437.9	350.3
Southern Bell	0.82	4,372.8	3,585.7	0.78	4,771.5	3,721.8	0.80	5,224.8	4,179.8
Ohio Bell	0.99	1,403.3	1,389.3	0.86	1,530.6	1,316.3	0.87	1,623.7	1,412.6
Michigan Bell	0.70	1,805.3	1,263.7	0.66	1,897.7	1,252.5	0.68	2,020.5	1,373.9
Indiana Bell	0.75	778.7	584.0	0.78	837.4	653.2	0.67	866.0	580.2
Wisconsin Telephone Co.	0.87	719.4	625.9	0.78	729.5	569.0	0.90	753.3	678.0
Illinois Bell	0.81	2,137.8	1,731.6	0.81	2,189.3	1,773.3	0.77	2,453.1	1,888.9
Northwestern Bell	0.85	1,868.9	1,588.6	0.82	1,996.5	1,637.1	0.82	2,162.5	1,773.3
Southwestern Bell	0.87	5,701.9	4,960.7	0.84	6,358.9	5,341.5	0.84	6,872.8	5,773.2
Mountain States T&T	0.89	2,450.1	2,180.6	0.89	2,873.6	2,557.5	0.84	3,309.1	2,779.6
Pacific Northwest Bell	0.93	1,220.6	1,135.2	0.88	1,283.8	1,129.7	0.92	1,740.2	1,601.0
		ΣV_i =	$29,250.9		ΣV_i =	$30,385.7		ΣV_i =	$33,381.5

Table 4-37
Market Values of Equity of AT&T, Western Electric and the Bell Operating Companies, 1979-1981
(Dollars in Millions)

Year	Market Values of Equity			
	Western Electric +	Bell Operating Companies =	Sum	AT&T
1979	$3,337.9	$29,250.9	$32,588.8	$36,564.0
1980	4,486.9	30,385.7	34,872.6	36,139.8
1981	4,641.8	33,381.5	38,023.3	47,887.1

values of equity of Western Electric and the Bell Operating Companies to the observed market value of equity of AT&T. From this comparison we note the following:

1. The market value of AT&T's equity is higher than the sum of the market values of Western Electric and the Bell Operating Companies in every year. In addition to any problems of estimation errors there are two reasons for this discrepancy. First, not all the equity holding of AT&T is included in the analysis. In addition to Western Electric and the Bell Operating Companies, AT&T's assets include its Long Line operations, Bell Laboratories and part ownership of Southern New England Telephone Co. and Cincinnati Bell. These assets have not been valued in this study. Second, within the Bell Operating Companies we did not have the necessary data to include South Central Bell and Pacific Telephone & Telegraph.

2. In 1981, our analysis showed that the operating companies constituted approximately 70 percent and Western Electric Company approximately 10 percent of the equity value of AT&T. This implies that about 20 percent of the equity value should be accounted for by values of AT&T holdings not included in the analysis--Bell Laboratory, Long Lines, South Central Bell, and Pacific Telephone and Telegraph.

Since we did not estimate the values of all of AT&T's equity holdings, because data were unavailable, we did not carry out the Value Additivity tests. However the methodology does hold out the promise that such tests can be carried out to assess the validity of the estimations of the equity values of all of AT&T's holdings.

CHAPTER V
SUMMARY AND CONCLUSIONS

To maximize shareholder wealth a firm should invest in only those of its projects, divisions or subsidiaries for which the present value of net future cash flows, discounted at the market's required rate of return or cost of capital, is positive. Thus a key element in the value-maximizing investment decision process of a firm is the estimation of cost of capital of the investment being evaluated. In the case of the regulated utility industries, the financial integrity of the firms and their ability to attract capital is maintained, only if regulators allow the firms to earn rates of return at least equal to their costs of capital. Again, a key element for effective regulation is the estimation of capital costs of utilities. In finance literature there are two major models for estimating the cost of capital--the Discounted Cash Flow (DCF) model and the Capital Asset Pricing Model (CAPM). These models are market models based on prices of financial assets. They can directly be implemented only to estimate cost of capital of firms that are traded in the capital markets. The estimate of the firm cost of capital can be used to make optimal investment and regulatory decisions if the projects, divisions and subsidiaries of the firm are of equal risk and thus have the same required rate of return. Where this is not so, it becomes necessary to obtain independent estimates of capital costs for these entities, commensurate with their risks. Since these entities are not traded in the capital markets, conventional cost of capital models cannot directly be used. Alternative models need to be developed.

In this study we present a survey of alternative methodologies for estimating the capital costs of non-traded assets. We apply the methodologies to estimate the cost of equity capital of electric utility subsidiaries, telephone industry subsidiaries, and Western Electric Company, a non-regulated subsidiary of a regulated parent, AT&T. The basic approach that we adopt is the Subsidiary Approach in which we regard each subsidiary as a separate entity, independent of its affiliation to the parent, with a unique cost of capital. Within the Subsidiary Approach there are two methods by which the subsidiary cost of capital can be estimated. In the "pure play" or analogy approach we identify a group of traded firms with risks comparable to the subsidiary being analyzed. The subsidiary cost of capital is then the average cost of capital of the comparable risk group. In the analytical approach we establish, econometrically, a relationship between risk/return and their real or fundamental determinants, which can be measured using the firm data. From this relationship we estimate the subsidiary capital costs. Within the analytical approach we developed four independent econometric models--based on (1) determinants of equity cost, (2) the Gordon valuation equation, (3) the CAPM equation and (4) the theory of the firm.

In the pure play approach applied to electric utility subsidiaries, we used bond rating as the single criterion for establishing the comparable risk group. To estimate the cost of equity of the firms within the risk group we used the constant growth DCF model, the nonconstant growth DCF model, the CAPM model with historical measures of market risk premium, the CAPM model with ex-ante measures of market risk premium and the risk premium approach. Based on a simple reasonableness criterion that the firm or the risk group with the higher bond rating should have a lower cost of equity, we conclude that the DCF estimates are more reliable.

In the analytical approach based on the real-determinants-of-equity cost, as applied to electric utility subsidiaries, we estimated a cross-sectional relationship, between the cost of equity and the relevant risk variables, for a sample of 79 operating utility companies. We tried alternative measures of the dependent variable based on the DCF model and CAPM; alternative specifications of the risk variables with alternative measurement techniques. The "best" results, in terms of goodness of fit and signs/significance of the regression coefficients, were obtained with the dependent variable, k, measured as the constant growth DCF cost of equity and equity risk measured as the accounting ROE beta, BROE. Thus the recommended specification is

$$k = f(\text{BROE, regulatory risk, nuclear risk})$$

The estimates of the cost of equity of selected subsidiaries by this approach and the pure play approach were not significantly different.

In the analytical approach based on the Gordon valuation equation, as applied to electric utility subsidiaries, the P/B ratio of the firms in the same sample of 79 operating utilities was specified to be a function of the expected rate of return on book equity, EROE, and the risk variables used in the previous approach. We tried alternative measures of EROE and the risk variables and based again on the R^2 value and signs/significance of coefficients, the "best" results were obtained with EROE measured as the normalized rate of return, NROE, and the risk variables measured as in the previous approach. Thus the recommended specification is

$$P/B = f(\text{NROE, BROE, regulatory risk, nuclear risk})$$

From the estimated regression equation we calculated the subsidiary cost of equity by setting $\widehat{P/B} = 1.0$ and solving for NROE. This computation is based on the theoretical relationship that the P/B ratio of a firm is equal to 1.0 when its expected return on book equity is equal to its market-determined cost of equity. From the regression equation we can also estimate the $\widehat{P/B}$ of the subsidiaries and knowing their book values of equity, B, we can estimate their market values of equity as $(\widehat{P/B})B$. This feature allows us to test for the validity of our estimates under the assumption of Value Additivity. We test for equality between (1) the observed market value of equity of the parent and the sum of the estimated market values of subsidiaries and (2) the cost of equity of the parent and the weighted sum of the estimated costs of equity of the subsidiaries; the weights being equity market value fractions. For the small sample of subsidiaries analyzed, we found the equalities to hold, validating our estimations.

In the analytical approach based on the CAPM, as applied to the electric utility subsidiaries we estimated, for the sample of 79 utilities, a relationship between P/B ratio, the expected return on equity, systematic equity risk and the firm's future growth. This model was developed by Litzenberger and Rao (1971) to estimate the cost of equity of traded utilities. However, since the model specifies the independent variables in terms of firm data only, it is amenable to the estimation of subsidiary equity costs. We replicated the Litzenberger-Rao model and also tried an improved specification and measurement technique. The modified specification produced better results, but even so the estimates of the coefficients and the resulting equity costs from this model were unreasonable. The best results were obtained with the specification

$$P/B = f(NROE, BROE, growth)$$

The problem with the model is that it tries to capture all the risk of the utility in a single measure--ROE variability.

In the analytical approach based on the theory of the firm, as applied to electric utility subsidiaries, we estimated a relationship, for the same sample of firms, between the firm beta, its factor proportions, L/K, and monopoly power, MP.

$$\beta = f(L/K, M/P)$$

This model is based on a rigorous theoretical development but because of severe problems in measuring the independent variables, produces unreliable results.

Comparing these alternative methodologies applied to the same sample of electric utilities we draw the following conclusions:

1. The pure play approach is a non-econometric approach that is easy to apply and can produce a good first approximation of subsidiary capital cost estimation. The accuracy of the estimate would depend largely on the appropriateness of the comparable risk group chosen. The method does not provide a complete differentiation between the risks of various subsidiaries nor does it provide any measure of estimation errors.
2. The analytical approach based on the real determinants of equity costs allows the inclusion of all risk variables in an econometric framework. It also provides measures of estimation error. The problem with this approach is that the specification is ad-hoc and has no theoretical basis. The R^2 values are typically low and the standard error of estimation high.
3. The analytical approach, based on the Gordon model, has as its basis a theoretical valuation equation. This approach allows us to estimate both the cost and market value of equity of the subsidiaries. Based on the market value estimates, we can carry out validity tests by testing for the equalities implied by Value Additivity. Because this model is based on theory and produces estimates that are testable this approach holds the most promise.
4. The analytical approach based on the CAPM, as developed by Litzenberger-Rao, also has the potential for testing the validity of the estimations but the specification of risk variables in this model is incomplete, at least for electric utilities. The estimates of the cost of utility subsidiaries are unreasonable.

5. The analytical approach based on the theory of the firm provides a theoretical relationship between firm beta and its microvariables--the factor proportions and monopoly power. The problems with measuring these variables make this approach difficult to implement.
6. Thus, of all the methodologies tested the two that we recommend are the pure play technique and the analytical approach based on the Gordon valuation equation.

We used these recommended methodologies to estimate the cost of equity of Western Electric, a non-regulated subsidiary, and the telephone operating subsidiaries of AT&T. In implementing the pure play approach to estimate Western Electric's cost of equity we used the 26 largest manufacturing companies, with bond rating of AA or AAA, as the comparable risk group. For the telephone subsidiary estimations, we used the 9 traded telephone companies as the comparable risk group. We used the Gordon valuation model to estimate the cost of equity and equity market values of Western Electric and the Bell Operating Companies.

In addition to the usefulness of these models in estimating subsidiary capital costs which help in investment and regulatory decisions, the methodologies developed in this study can be used to address other issues, such as:

1. Valuation of closely held firms that plan to go public. With the impending divestiture of AT&T the question of the valuation of the operating companies is a relevant and important issue.
2. The question of cross-subsidization in regulated utilities. Generally speaking in regulatory proceedings very little attempt is

> made to differentiate among risk/returns of the various subsidiaries of a holding company. If the same rate of return, based on the parent's cost of capital, is allowed for all subsidiaries then to the extent that these subsidiaries have different risks, the customers of the low-risk subsidiary subsidize those of the high-risk subsidiary.

These are areas for future research.

APPENDIX
REGRESSION RESULTS

Table A-1
Composition of the Comparable Risk Groups
Based on S&P Bond Ratings, 1977-1981

Year	AA Bond Rating	A Bond Rating	BBB Bond Rating
1977	Baltimore Gas & Elec.	Arizona Public Service Co.	Boston Edison Co.
	Central Illinois Pub. Serv.	Atlantic City Elec.	Central Maine Power Co.
	Cincinnati Gas & Elec.	Carolina Power & Light	Detroit Edison Co.
	Cleveland Elec. Illum.	Central Hudson G&E	Missouri Public Service Co.
	Commonwealth Edison	Central Illinois Light	Nevada Power Co.
	Duquesne Light Co.	Consolidated Edison	Orange & Rockland Util.
	Gulf States Utilities	Consumers Power Co.	Pacific Gas & Elec.
	Illinois Power Co.	Dayton Power & Light	Pacific Power & Light
	Indianapolis Power & Light	Delmarva Power & Light	Pub. Service of N. Hamp.
	Iowa Illinois Gas & Elec.	Duke Power Co.	Puget Sound Power & Light
	Iowa Pub. Serv. Co.	Empire District Elec.	San Diego Gas & Elec.
	Kansas Gas & Elec.	Florida Power & Light	
	Kansas Power & Light	Florida Progress Corp.	
	Kentucky Utilities	Hawaiian Elec. Co.	
	Louisville Gas & Elec.	Idaho Power Co.	
	Northern Indiana Pub. Serv.	Interstate Power Co.	
	Northern States Power	Iowa Elec. Power & Light	
	Oklahoma Gas & Elec.	Kansas City Power & Light	
	Pacific Gas & Elec.	Long Island Lighting	
	Public Service E&G	Minn. Power & Light	
	Public Service Co. of Colorado	N.Y. State E&G	
	Public Service Co. of Indiana	Niagara Mohawk Power	
	Public Service Co. of N. Mexico	Ohio Edison	
	Southern Cal Edison	Penn Power & Light	
	Southern Indiana Gas & Elec.	Philadelphia Elec.	
	S.W. Pub. Serv. Co.	Potomac Elec. Power	
	TECO Energy Inc.	Rochester Gas & Elec.	
	Utah Power & Light	St. Joseph Light & Power	
	Wisconsin Elec. Power	Sierra Pacific Power	
	Wisconsin Power & Light	S. Carolina E&G	
	Wisconsin Pub. Serv.	Toledo Edison	
		Tucson Elec. Power	
		Union Elec. Co.	
		Virginia Elec. & Power Co.	

Table A-1
(Continued)

Year	AA Bond Rating	A Bond Rating	BBB Bond Rating
1978	Baltimore Gas & Elec.	Arizona Pub. Serv. Co.	Boston Edison Co.
	Central Illinois Pub. Serv.	Atlantic City Elec.	Central Maine Power Co.
	Cincinnati Gas & Elec.	Carolina Power & Light	Detroit Edison Co.
	Cleveland Elec. Illum.	Central Hudson G&E	Missouri Pub. Serv. Co.
	Commonwealth Edison	Central Illinois Light	Nevada Power Co.
	Duquesne Light Co.	Consolidated Edison	Pacific Gas & Elec.
	Illinois Power Co.	Consumers Power Co.	Pacific Power & Light
	Indianapolis Power & Light	Dayton Power & Light	Pub. Serv. Co. of New Hamp.
	Iowa Illinois Gas & Elec.	Delmarva Power & Light	Puget Sound Power & Light
	Iowa Pub. Serv. Co.	Duke Power Co.	San Diego Gas & Elec.
	Kansas Power & Light	Empire District Elec.	Savannah Elec. & Power
	Kentucky Utilities	Florida Power & Light	United Illuminating
	Louisville Gas & Elec.	Florida Progress Corp.	
	Northern Indiana Pub. Serv.	Gulf States Utilities	
	Northern States Power	Hawaiian Elec. Co.	
	Oklahoma Gas & Elec.	Idaho Power Co.	
	Pacific Gas & Elec.	Interstate Power Co.	
	Pub. Serv. E&G	Iowa Elec. Power & Light	
	Pub. Serv. Co. of Colorado	Kansas City Power & Light	
	Pub. Serv. Co. of Indiana	Kansas Gas & Elec.	
	Pub. Serv. Co. of New Mexico	Long Island Lighting	
	Southern Cal Edison	Minn. Power & Light	
	Southern Indiana Gas & Elec.	Montana Power Co.	
	S.W. Pub. Serv. Co.	New York State E&G	
	TECO Energy Inc.	Niagara Mohawk Power	
	Utah Power & Light	Ohio Edison	
	Wisconsin Elec. Power	Orange & Rockland Ut.	
	Wisconsin Power & Light	Penn Power & Light	
	Wisconsin Pub. Serv.	Philadelphia Elec.	
		Potomac Elec. Power	
		Rochester Gas & Elec.	
		St. Joseph Light & Power	
		Sierra Pacific Power	
		S. Carolina E&G	
		Toledo Edison	
		Tucson Elec. Power	
		Union Elec. Co.	
		Virginia Elec. & Power Co.	

Table A-1
(Continued)

Year	AA Bond Rating	A Bond Rating	BBB Bond Rating
1979	Baltimore Gas & Elec.	Arizona Public Service Co.	Boston Edison Co.
	Central Illinois Pub. Serv.	Atlantic City Elec.	Central Maine Power Co.
	Cincinnati Gas & Elec.	Carolina Power & Light	Detroit Edison Co.
	Cleveland Elec. Illum.	Central Hudson G&E	Missouri Public Service Co.
	Commonwealth Edison	Central Illinois Light	Nevada Power Co.
	Duquesne Light Co.	Consolidated Edison	Pacific Gas & Elec.
	Illinois Power Co.	Consumers Power Co.	Pacific Power & Light
	Indianapolis Power & Light	Dayton Power & Light	Pub. Service of N. Hamp.
	Iowa Illinois Gas & Elec.	Delmarva Power & Light	Puget Sound Power & Light
	Iowa Pub. Serv. Co.	Duke Power Co.	San Diego Gas & Elec.
	Kansas Power & Light	Empire District Elec.	Savannah Elec. & Power
	Kentucky Utilities	Florida Power & Light	United Illuminating
	Louisville Gas & Elec.	Florida Progress Corp.	
	Northern Indiana Pub. Serv.	Gulf States Utilities	
	Northern States Power	Hawaiian Elec. Co.	
	Oklahoma Gas & Elec.	Idaho Power Co.	
	Pacific Gas & Elec.	Interstate Power Co.	
	Public Service E&G	Iowa Elec. Power & Light	
	Public Service Co. of Colorado	Kansas City Power & Light	
	Public Service Co. of Indiana	Minn. Power & Light	
	Public Service Co. of N. Mexico	Montana Power Co.	
	Southern Cal Edison	N.Y. State E&G	
	Southern Indiana Gas & Elec.	Niagara Mohawk Power	
	S.W. Pub. Serv. Co.	Ohio Edison	
	TECO Energy Inc.	Orange & Rockland Ut.	
	Utah Power & Light	Penn Power & Light	
	Wisconsin Elec. Power	Philadelphia Elec.	
	Wisconsin Power & Light	Potomac Elec. Power	
	Wisconsin Pub. Serv.	Rochester Gas & Elec.	
		St. Joseph Light & Power	
		Sierra Pacific Power	
		S. Carolina E&G	
		Toledo Edison	
		Tucson Elec. Power	
		Union Elec. Co.	
		Virginia Elec. & Power Co.	

Table A-1
(Continued)

Year	AA Bond Rating	A Bond Rating	BBB Bond Rating
1980	Baltimore Gas & Elec.	Arizona Public Service Co.	Boston Edison Co.
	Central Illinois Pub. Serv.	Atlantic City Elec.	Central Maine Power Co.
	Cincinnati Gas & Elec.	Carolina Power & Light	Consumers Power Co.
	Cleveland Elec. Illum.	Central Hudson G&E	Dayton Power & Light
	Duquesne Light Co.	Central Illinois Light	Detroit Edison Co.
	Illinois Power Co.	Commonwealth Edison	Kansas Gas & Elec.
	Indianapolis Power & Light	Consolidated Edison	Long Island Lighting
	Iowa Illinois Gas & Elec.	Delmarva Power & Light	Missouri Public Service Co.
	Iowa Pub. Serv. Co.	Duke Power Co.	Nevada Power Co.
	Kansas Power & Light	Duquesne Light Co.	N.Y. State E&G
	Kentucky Utilities	Empire District Elec.	Ohio Edison Co.
	Louisville Gas & Elec.	Florida Power & Light	Pacific Gas & Elec.
	Northern Indiana Pub. Serv.	Florida Progress Corp.	Pacific Power & Light
	Northern States Power	Gulf States Utilities	Philadelphia Elec. Co.
	Pacific Gas & Elec.	Hawaiian Elec. Co.	Pub. Service of N. Hamp.
	Public Service E&G	Idaho Power Co.	Puget Sound Power & Light
	Public Service Co. of Indiana	Interstate Power Co.	San Diego Gas & Elec.
	Public Service Co. of N. Mexico	Iowa Elec. Power & Light	Savannah Elec. & Power
	Southern Cal Edison	Kansas City Power & Light	Toledo Edison Co.
	Southern Indiana Gas & Elec.	Minn. Power & Light	
	S.W. Pub. Serv. Co.	Montana Power Co.	
	TECO Energy Inc.	Niagara Mohawk Power	
	Utah Power & Light	Oklahoma Gas & Elec.	
	Wisconsin Elec. Power	Orange & Rockland Ut.	
	Wisconsin Power & Light	Penn Power & Light	
	Wisconsin Pub. Serv.	Potomac Elec. Power	
		Public Serv. of Colorado	
		Rochester Gas & Elec.	
		St. Joseph Light & Power	
		Sierra Pacific Power	
		S. Carolina E&G	
		Tucson Elec. Power	
		Union Elec. Co.	
		Virginia Elec. & Power Co.	

Table A-1
(Continued)

Year	AA Bond Rating	A Bond Rating	BBB Bond Rating
1981	Baltimore Gas & Elec.	Arizona Pub. Serv. Co.	Boston Edison Co.
	Central Illinois Pub. Serv.	Atlantic City Elec.	Central Maine Power Co.
	Cincinnati Gas & Elec.	Carolina Power & Light	Consumers Power Co.
	Cleveland Elec. Illum.	Central Hudson G&E	Dayton Power & Light
	Duquesne Light Co.	Central Illinois Light	Detroit Edison Co.
	Illinois Power Co.	Commonwealth Edison	Duquesne Light Co.
	Indianapolis Power & Light	Consolidated Edison	Kansas Gas & Elec.
	Iowa Illinois Gas & Elec.	Delmarva Power & Light	Long Island Lighting
	Iowa Pub. Serv. Co.	Duke Power Co.	Missouri Pub. Serv. Co.
	Kansas Power & Light	Empire District Elec.	Nevada Power Co.
	Louisville Gas & Elec.	Florida Power & Light	New York State E&G
	Northern States Power	Florida Progress Corp.	Ohio Edison Co.
	Pub. Serv. E&G	Gulf States Utilities	Pacific Gas & Elec.
	Pub. Serv. Co. of New Mexico	Hawaiian Elec. Co.	Pacific Power & Light
	Southern Cal Edison	Idaho Power Co.	Philadelphia Elec. Co.
	Southern Indiana Gas & Elec.	Interstate Power Co.	Pub. Serv. Co. of New Hamp.
	S.W. Pub. Serv. Co.	Iowa Elec. Power & Light	Puget Sound Power & Light
	TECO Energy Inc.	Kansas City Power & Light	San Diego Gas & Elec.
	Wisconsin Elec. Power	Kentucky Utilities	Sierra Pac. Power
	Wisconsin Power & Light	Minn. Power & Light	Savannah Elec. & Power
	Wisconsin Pub. Serv.	Montana Power Co.	Toledo Edison Co.
		Niagara Mohawk Power	Union Elec. Co.
		North. Indiana Pub. Serv.	
		Oklahoma Gas & Elec.	
		Orange & Rockland Ut.	
		Penn Power & Light	
		Potomac Elec. Power	
		Pub. Serv. of Colorado	
		Pub. Serv. of Indiana	
		Rochester Gas & Elec.	
		St. Joseph Light & Power	
		S. Carolina E&G	
		Tucson Elec. Power	
		Utah Power & Light	
		Virginia Elec. & Power Co.	

Table A-2
Average Equity Costs of the Risk Classes,
1977-1981

	Bond Rating: AA				Bond rating: A				Bond Rating: BBB			
Year	k_1	k_2	k_3	k_4	k_1	k_2	k_3	k_4	k_1	k_2	k_3	k_4
1977	11.86%	13.11%	12.27%	12.01%	11.92%	13.44%	12.68%	12.39%	11.51%	13.00%	12.36%	12.10%
1978	13.28	14.47	12.79	12.41	13.39	14.76	13.25	13.41	13.76	14.80	12.85	12.99
1979	14.62	15.70	14.49	14.78	14.96	16.14	14.75	15.07	15.05	16.15	14.63	14.99
1980	16.08	17.04	14.48	14.31	16.00	16.87	14.43	14.24	16.16	17.20	14.73	14.51
1981	15.96	16.59	16.26	15.46	15.57	16.86	16.18	15.41	16.25	17.31	16.19	15.42

Table A-3
Sample of Electric Utility Firms
Used in the Regression Analysis

No.	Company	No.	Company
1	Atlantic City Elec.	41	Nevada Power Co.
2	Arizona Pub. Serv. Co.	42	N.Y. State Elec. & Gas
3	Baltimore Gas & Elec.	43	Niagara Mohawk Power
4	Boston Edison Co.	44	Northern Indiana Pub. Serv.
5	Carolina Power & Light	45	Northern States Power
6	Central Hudson Gas & Elec.	46	Ohio Edison Co.
7	Central Illinois Light	47	Oklahoma Gas & Elec.
8	Central Illinois Pub. Serv.	48	Orange & Rockland Utilities
9	Central Maine Power Co.	49	Pacific Gas & Elec.
10	Cincinnati Gas & Elec.	50	Pacific Power & Light
11	Cleveland Elec. Illum.	51	Pennsylvania Power & Light
12	Commonwealth Edison	52	Philadelphia Elec. Co.
13	Consolidated Edison of N.Y.	53	Portland General Elec. Co.
14	Consumers Power Co.	54	Potomac Elec. Power
15	Dayton Power & Light	55	Pub. Serv. Co. of Colorado
16	Delmarva Power & Light	56	Pub. Serv. Elec. & Gas
17	Detroit Edison Co.	57	Pub. Serv. Co. of Indiana
18	Duke Power Co.	58	Pub. Serv. Co. of New Hamp.
19	Duquesne Light Co.	59	Pub. Serv. Co. of New Mexico
20	Empire District Elec. Co.	60	Puget Sound Power & Light
21	Florida Power & Light	61	Rochester Gas & Elec.
22	Florida Progress Corp.	62	St. Joseph Light & Power
23	Gulf States Utilities Co.	63	Savannah Elec. & Power
24	Hawaiian Elec. Co.	64	San Diego Gas & Elec.
25	Idaho Power Co.	65	Sierra Pacific Power Co.
26	Illinois Power Co.	66	Southern Cal Edison Co.
27	Indianapolis Power & Light	67	South Carolina Elec. & Gas
28	Interstate Power Co.	68	Southern Indiana Gas & Elec.
29	Iowa Elec. Light & Power	69	Southwestern Pub. Serv. Co.
30	Iowa-Illinois Gas & Elec	70	TECO Energy Inc.
31	Iowa Public Service Co.	71	Toledo Edison Co.
32	City Power & Light	72	Tucson Elec. Power Co.
33	Kansas Gas & Elec.	73	Union Electric Co.
34	Kansas Power & Light	74	United Illum. Co.
35	Kentucky Utilities Co.	75	Utah Power & Light
36	Long Island Lighting	76	Virginia Elec. & Power
37	Louisville Gas & Elec.	77	Wisconsin Elec. Power
38	Minnesota Power & Light	78	Wisconsin Power & Light
39	Missouri Pub. Serv. Co.	79	Wisconsin Pub. Serv.
40	Montana Power Co.		

Table A-4
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_1)_i = a_0 + a_1(BROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1037 (6.36)	0.0017 (0.56)	0.0384 (0.87)	0.0136 (1.83)	0.0037 (1.40)	-0.1609 (-3.25)	-0.0084 (-1.42)	0.1097	0.0101	0.0787
1978	0.1192 (6.48)	0.0037 (1.08)	0.0412 (0.84)	0.0100 (1.13)	0.0059 (1.92)	-0.1685 (-2.56)	-0.0137 (-2.02)	0.1153	0.0116	0.0891
1979	0.1353 (7.63)	0.0060 (1.70)	0.0270 (0.58)	0.0170 (1.93)	0.0087 (2.73)	-0.1038 (-1.48)	-0.01981 (-2.48)	0.1622	0.0116	0.1018
1980	0.1624 (7.52)	0.0150 (3.74)	-0.0210 (-0.38)	0.0208 (2.28)	0.0046 (1.04)	-0.0606 (-0.74)	-0.0131 (-1.39)	0.1236	0.0141	0.1200
1981	0.1580 (8.71)	0.0094 (2.74)	-0.0148 (-0.32)	0.0235 (3.43)	0.0035 (0.81)	-0.0949 (-1.36)	-0.0188 (-2.22)	0.1580	0.0123	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_1 is the constant growth DCF cost of equity capital.

Table A-5
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_2)_i = a_0 + a_1(BROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1332 (6.91)	-0.0003 (-0.10)	0.0434 (0.98)	0.0094 (1.24)	0.0054 (2.03)	-0.0031 (-0.06)	-0.0056 (-1.94)	0.0300	0.0102	0.0787
1978	0.1300 (9.03)	0.0022 (0.83)	0.0286 (0.75)	0.0194 (2.80)	0.0031 (1.27)	0.0322 (0.63)	-0.0111 (2.09)	0.0900	0.0091	0.0891
1979	0.1627 (10.98)	0.0028 (0.95)	-0.0307 (-0.78)	0.0194 (2.64)	0.0029 (1.11)	0.0580 (0.99)	-0.0082 (-1.22)	0.1291	0.0097	0.1018
1980	0.1648 (11.32)	0.0111 (4.09)	-0.0153 (-0.41)	0.0231 (3.76)	0.0026 (0.87)	0.0329 (0.60)	0.0039 (0.62)	0.2382	0.0095	0.1200
1981	0.1701 (11.76)	0.0048 (1.77)	-0.0263 (-0.71)	0.0176 (3.22)	0.0047 (1.38)	0.1111 (2.00)	-0.0093 (-1.37)	0.1830	0.0098	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_2 is the non-constant growth DCF cost of equity capital with Value Line forecasts.

Table A-6
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_3)_i = a_0 + a_1(BROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1440 (8.60)	0.0063 (2.03)	-0.0736 (-1.63)	0.0224 (2.94)	-0.0252 (-0.93)	-0.0274 (-0.54)	-0.0035 (-0.57)	0.1229	0.0104	0.0787
1978	0.1313 (8.41)	0.0070 (2.42)	-0.0229 (-0.55)	0.0176 (2.35)	-0.0013 (-0.50)	0.0652 (1.17)	-0.0000 (0.00)	0.0665	0.0099	0.0891
1979	0.1310 (9.11)	0.0014 (0.48)	0.0336 (0.88)	0.0074 (1.04)	-0.0001 (-0.06)	-0.0101 (-0.18)	0.0102 (1.58)	0.0046	0.0094	0.1018
1980	0.1427 (14.30)	-0.0042 (-2.26)	0.0075 (0.29)	-0.0044 (-1.04)	0.0000 (0.00)	0.0445 (1.18)	0.0044 (1.01)	0.0121	0.0085	0.1200
1981	0.1617 (17.95)	-0.0058 (-3.40)	0.0098 (0.42)	-0.0068 (-2.00)	0.0006 (0.32)	-0.0611 (-1.77)	0.0059 (1.34)	0.1011	0.0091	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_3 is the CAPM equity cost with historical (Ibbotson-Sinquefield) measures of market risk premium.

Table A-7
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_4)_i = a_0 + a_1(BROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1406 (8.90)	0.0059 (2.03)	-0.0692 (-1.63)	0.0211 (2.94)	-0.0024 (-0.93)	-0.0258 (-0.54)	-0.0033 (-0.57)	0.1229	0.0098	0.0787
1978	0.1328 (8.21)	0.0072 (2.42)	-0.0238 (-0.55)	0.0183 (2.34)	-0.0014 (-0.50)	0.0676 (1.17)	-0.0000 (-0.00)	0.0665	0.0102	0.0891
1979	0.1331 (8.64)	0.0015 (0.48)	0.0359 (0.88)	0.0079 (1.04)	-0.0002 (-0.06)	-0.0108 (-0.18)	0.0110 (1.58)	0.0042	0.0101	0.1018
1980	0.1409 (15.35)	-0.0039 (-2.26)	0.0069 (0.29)	-0.0040 (-1.04)	0.0000 (0.00)	0.0410 (1.18)	0.0040 (1.00)	0.0121	0.0060	0.1200
1981	0.1541 (27.07)	-0.0036 (-3.40)	0.0062 (0.42)	-0.0043 (-2.00)	0.0004 (0.32)	-0.0386 (-1.77)	0.0037 (1.40)	0.1011	0.0089	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_4 is the CAPM equity cost with ex-ante measures of market risk premium.

Table A-8
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_1)_i = a_0 + a_1(SROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.0958 (6.50)	1.7860 (3.62)	0.0295 (0.75)	0.1176 (1.74)	0.0017 (0.70)	-0.1016 (-2.09)	-0.0086 (-1.62)	0.2433	0.0093	0.0787
1978	0.1053 (6.76)	1.4910 (2.64)	0.0528 (1.14)	0.0057 (0.69)	0.0043 (1.41)	-0.0949 (-1.35)	-0.0114 (-1.80)	0.1869	0.0112	0.0891
1979	0.1157 (6.76)	1.843 (3.56)	0.0478 (1.11)	0.0010 (1.30)	0.0061 (1.98)	-0.0417 (-0.60)	-0.0133 (-1.86)	0.2590	0.0109	0.1018
1980	0.1333 (6.16)	2.796 (4.38)	0.0116 (0.22)	-0.0004 (-0.05)	0.0014 (0.32)	0.0322 (0.39)	0.0047 (0.53)	0.1736	0.0137	0.1200
1981	0.1430 (7.49)	1.345 (2.18)	0.0008 (0.02)	0.0083 (1.16)	0.0028 (0.63)	-0.0192 (-0.23)	-0.0089 (-1.07)	0.1279	0.0125	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_1 is the constant growth DCF cost of equity capital.

Table A-9
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_2)_i = a_0 + a_1(SROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1091 (7.16)	1.500 (2.94)	0.0296 (0.73)	0.0084 (1.20)	0.0038 (1.48)	0.0478 (0.95)	-0.0065 (-1.19)	0.1098	0.0097	0.0787
1978	0.1213 (8.54)	0.9416 (2.10)	0.0355 (0.98)	0.0168 (2.55)	0.0020 (0.85)	0.0791 (1.42)	-0.0097 (-1.92)	0.1366	0.0088	0.0891
1979	0.1552 (10.28)	0.6739 (1.45)	-0.0214 (-0.56)	0.0163 (2.40)	0.0020 (0.75)	0.0787 (1.29)	-0.0054 (-0.85)	0.1512	0.0096	0.1018
1980	0.1512 (9.43)	1.1340 (2.39)	0.0076 (0.19)	0.0095 (1.59)	0.0017 (0.53)	0.0662 (1.08)	0.0146 (2.22)	0.1302	0.0101	0.1200
1981	0.1594 (10.77)	1.0650 (2.23)	-0.0189 (-0.52)	0.0077 (1.39)	0.0040 (1.19)	0.1749 (2.76)	-0.0343 (-0.55)	0.1956	0.0097	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_2 is the non-constant growth DCF cost of equity with Value Line growth forecasts.

Table A-10
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_3)_i = a_0 + a_1(\mathrm{SROI})_i + a_2(\mathrm{EQR})_i + a_3(\mathrm{AFUDC/NI})_i + a_4(\mathrm{FT})_i + a_5(\Delta\mathrm{ROE})_i + a_6(\mathrm{NUK})_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1386 (8.22)	-0.4902 (-0.87)	-0.0459 (-1.02)	0.0204 (2.64)	-0.0021 (-0.74)	-0.0477 (-0.86)	-0.0005 (-0.08)	0.0824	0.0107	0.0787
1978	0.1270 (7.74)	-0.2828 (-0.55)	0.0003 (0.01)	0.0134 (1.77)	-0.0012 (-0.43)	0.0198 (0.31)	0.0030 (0.52)	0.005	0.0103	0.0891
1979	0.1341 (9.12)	-0.4538 (-1.02)	0.0359 (0.97)	0.0066 (1.00)	0.0006 (0.23)	-0.0343 (-0.58)	0.0106 (1.73)	0.0153	0.0094	0.1018
1980	0.1467 (13.86)	-0.2908 (-0.93)	-0.0010 (-0.04)	0.0005 (0.12)	0.0001 (0.05)	0.0371 (0.92)	0.0007 (0.16)	0.0457	0.0068	0.1200
1981	0.1658 (16.56)	-0.2089 (-0.65)	-0.0009 (-0.04)	-0.0009 (-0.23)	0.0006 (0.26)	-0.0665 (-1.55)	0.0011 (0.25)	0.0368	0.0066	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_3 is the CAPM equity cost with historical (Ibbotson-Sinquefield) measures of market risk premium.

Table A-11
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M1

Regression: $(k_4)_i = a_0 + a_1(SROI)_i + a_2(EQR)_i + a_3(AFUDC/NI)_i + a_4(FT)_i + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE	R_F
1977	0.1350 (8.52)	-0.4611 (-0.87)	-0.0432 (-1.02)	0.0192 (2.64)	-0.0020 (-0.74)	-0.0450 (-0.86)	-0.0005 (-0.08)	0.0824	0.0100	0.0787
1978	0.1283 (7.56)	-0.2931 (-0.55)	0.0003 (0.00)	0.0139 (1.77)	-0.0012 (-0.43)	0.0205 (0.31)	0.0031 (0.52)	0.005	0.0103	0.0891
1979	0.1364 (8.67)	-0.4859 (-1.02)	0.0384 (0.97)	0.0070 (1.00)	0.0007 (0.23)	-0.0368 (-0.58)	0.0114 (1.73)	0.0153	0.0106	0.1018
1980	0.1445 (14.85)	-0.2674 (-0.93)	-0.0009 (-0.04)	0.0005 (0.12)	0.0000 (0.05)	0.0342 (0.92)	0.0006 (0.16)	0.0457	0.0061	0.1200
1981	0.1567 (24.77)	-0.1319 (-0.65)	-0.0006 (-0.04)	-0.0005 (-0.23)	0.0004 (0.26)	-0.0420 (-1.55)	0.0007 (0.25)	0.0368	0.0041	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_4 is the CAPM equity cost with ex-ante measures of market risk premium.

Table A-12
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_2)_i = a_0 + a_1(BROE)_i + a_2(AFUDC/NI)_i + a_3(FT)_i + a_4(\Delta ROE)_i + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1301 (48.29)	0.0046 (1.64)	0.0091 (1.31)	0.0039 (1.46)	0.0407 (0.75)	-0.0063 (-1.10)	0.0388	0.0100	0.0787
1978	0.1417 (59.11)	0.0056 (2.43)	0.0188 (3.02)	0.0016 (0.66)	0.0894 (1.62)	-0.0111 (-2.24)	0.1533	0.0088	0.0891
1979	0.1520 (62.44)	0.0043 (1.59)	0.0209 (3.28)	0.0015 (0.54)	0.1018 (1.55)	-0.0084 (-1.37)	0.1550	0.0096	0.1018
1980	0.1626 (62.09)	0.0073 (3.04)	0.0170 (3.13)	-0.0000 (-0.01)	0.0923 (1.52)	0.0100 (1.59)	0.1777	0.0098	0.1200
1981	0.1618 (68.47)	0.0545 (2.53)	0.0172 (3.74)	0.0032 (0.94)	0.1527 (2.66)	-0.0829 (-1.31)	0.2180	0.0095	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_2 is the non-constant growth DCF cost of equity capital with Value Line growth forecasts.

Table A-13
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_3)_i = a_0 + a_1(\text{BROE})_i + a_2(\text{AFUDC/NI})_i + a_3(\text{FT})_i + a_4(\Delta\text{ROE})_i + a_5(\text{NUK})_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1185 (41.10)	0.0009 (0.31)	0.0236 (3.18)	-0.0024 (-0.84)	-0.0293 (-0.51)	-0.0025 (-0.41)	0.0710	0.0107	0.0787
1978	0.1251 (45.29)	0.0025 (0.95)	0.0144 (2.01)	-0.0022 (-0.79)	0.0654 (1.03)	0.0023 (0.39)	0.0168	0.0104	0.0891
1979	0.1443 (60.47)	-0.0025 (-0.94)	0.0022 (0.35)	0.0009 (0.35)	-0.0146 (-0.71)	0.0134 (2.23)	0.0132	0.0094	0.1018
1980	0.1442 (82.98)	-0.0028 (-1.77)	-0.0022 (-0.61)	0.0011 (0.49)	0.0208 (0.52)	0.0021 (0.50)	0.0005	0.0065	0.1200
1981	0.1635 (105.3)	-0.0035 (-2.47)	-0.0037 (-1.22)	0.1152 (0.69)	-0.0839 (-2.23)	0.0030 (0.73)	0.0510	0.0063	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_3 is the CAPM equity cost with historical (Ibbotson-Sinquefield) measures of market risk premium.

Table A-14
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_4)_i = a_0 + a_1(\text{BROE})_i + a_2(\text{AFUDC/NI})_i + a_3(\text{FT})_i + a_4(\Delta\text{ROE})_i + a_5(\text{NUK})_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1162 (42.82)	0.0009 (0.31)	0.0221 (3.18)	-0.0022 (-0.84)	-0.0276 (-0.51)	-0.0023 (-0.41)	0.0710	0.0101	0.0787
1978	0.1264 (44.17)	0.0026 (0.95)	0.0149 (2.01)	-0.0023 (-0.79)	0.0677 (1.03)	0.0024 (0.39)	0.0168	0.0105	0.0891
1979	0.1473 (57.63)	-0.0026 (-0.94)	0.0023 (0.35)	0.0010 (0.35)	-0.0489 (-0.71)	0.0144 (2.24)	0.0132	0.0101	0.1018
1980	0.1423 (89.01)	-0.0026 (-1.76)	-0.0020 (-0.62)	0.0010 (0.49)	0.0191 (0.52)	0.0019 (0.51)	0.0005	0.0060	0.1200
1981	0.1552 (58.30)	-0.0022 (-2.45)	-0.0023 (-1.22)	0.0009 (0.69)	-0.0530 (-2.23)	0.0019 (0.73)	0.0510	0.0096	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_4 is the CAPM equity cost with ex-ante measures of market risk premium.

Table A-15
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_1)_i = a_0 + a_1(SROE)_i + a_2(AFUDC/NI)_i + a_3(FT)_i + a_4(\Delta ROE)_i + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1221 (29.89)	0.5330 (2.50)	0.0032 (0.50)	0.0032 (1.26)	-0.1520 (-3.11)	-0.0058 (-1.04)	0.1240	0.0100	0.0787
1978	0.1368 (28.90)	0.3040 (1.27)	0.0112 (1.63)	0.0061 (1.95)	-0.1767 (-2.70)	-0.0106 (-1.65)	0.0992	0.0118	0.0891
1979	0.1492 (31.71)	0.0732 (-0.27)	0.0047 (0.57)	0.0091 (2.82)	-0.1182 (-1.65)	-0.0014 (-1.86)	0.1326	0.0118	0.1018
1980	0.1578 (27.32)	0.1113 (0.42)	0.0087 (1.13)	0.0062 (1.32)	-0.0894 (-0.99)	-0.0024 (-0.25)	0.0270	0.0152	0.1200
1981	0.1553 (30.50)	0.1845 (0.57)	0.0051 (0.64)	0.0038 (0.86)	-0.1083 (-1.45)	-0.0117 (-1.39)	0.0831	0.0128	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_1 is the constant growth DCF cost of equity capital.

Table A-16
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_2)_i = a_0 + a_1(SROE)_i + a_2(AFUDC/NI)_i + a_3(FT)_i + a_4(\Delta ROE)_i + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1281 (30.89)	0.1220 (0.51)	0.0065 (0.93)	0.0050 (1.91)	0.0004 (0.01)	-0.0048 (-0.84)	0.0069	0.0102	0.0787
1978	0.1421 (38.59)	-0.0545 (-0.26)	0.0160 (2.50)	0.0032 (1.32)	0.0279 (0.55)	-0.0091 (-1.79)	0.0857	0.0091	0.0891
1979	0.1520 (39.24)	0.0136 (0.06)	0.0185 (2.93)	0.0029 (1.12)	0.0491 (0.83)	-0.0071 (-1.15)	0.1259	0.0098	0.1018
1980	0.1646 (41.55)	-0.1025 (-0.46)	0.0117 (2.14)	0.0035 (1.11)	0.0290 (0.47)	0.0117 (1.75)	0.0764	0.0104	0.1200
1981	0.1608 (40.67)	0.0558 (0.28)	0.0143 (3.05)	0.0048 (1.40)	0.1079 (1.86)	-0.0058 (-0.90)	0.1506	0.0100	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_2 is the non-constant growth DCF cost of equity capital with Value Line growth forecasts.

Table A-17
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_3)_i = a_0 + a_1(SROE)_i + a_2(AFUDC/NI)_i + a_3(FT)_i + a_4(\Delta ROE)_i + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1137 (26.40)	0.3672 (1.45)	0.0220 (3.05)	-0.0022 (-0.80)	-0.0427 (-0.83)	-0.0029 (-0.48)	0.0959	0.0106	0.0787
1978	0.1225 (29.95)	0.1899 (0.82)	0.0124 (1.75)	-0.0014 (-0.52)	0.0294 (0.52)	0.0031 (0.55)	0.0135	0.0102	0.0891
1979	0.1395 (37.82)	0.3489 (1.67)	0.0032 (0.54)	0.0003 (0.10)	-0.0331 (-0.59)	0.0128 (2.18)	0.0381	0.0093	0.1018
1980	0.1407 (56.79)	0.2540 (1.84)	-0.0003 (-0.08)	-0.0002 (-0.08)	0.0297 (0.77)	0.0016 (0.38)	0.0026	0.0065	0.1200
1981	0.1596 (63.23)	0.2588 (2.03)	-0.0027 (-0.92)	0.0003 (0.16)	-0.0339 (-0.92)	0.0021 (0.50)	0.0270	0.0063	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_3 is the CAPM equity cost with historical (Ibbotson-Sinquefield) measures of market risk premium.

Table A-18
Regression Results Based on Determinants of Equity-Cost Model, 1977-1981

Model: M2

Regression: $(k_4)_i = a_0 + a_1(SROE)_i + a_2(AFUDC/NI)_i + a_3(FT)_i + a_4(\Delta ROE)_i + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE	R_F
1977	0.1116 (27.55)	0.3455 (1.45)	0.0207 (3.05)	-0.0020 (-0.80)	-0.0402 (-0.83)	-0.0027 (-0.48)	0.0959	0.0105	0.0787
1978	0.1238 (29.19)	0.1968 (0.82)	0.0128 (1.75)	-0.0014 (-0.52)	0.0305 (0.52)	0.0032 (0.55)	0.0135	0.0105	0.0891
1979	0.1421 (36.00)	0.3735 (1.67)	0.0035 (0.54)	0.0003 (0.10)	-0.0354 (-0.59)	0.0137 (2.18)	0.0381	0.0100	0.1018
1980	0.1390 (61.03)	0.2336 (1.84)	-0.0027 (-0.85)	-0.0001 (-0.08)	0.0273 (0.77)	0.0015 (0.38)	0.0026	0.0062	0.1200
1981	0.1527 (65.82)	0.1634 (2.03)	-0.0173 (-0.92)	0.0002 (0.16)	-0.0214 (-0.91)	0.0013 (0.50)	0.0266	0.0082	0.1400

Notes: (1) Figures in parentheses are t values.

(2) R_F is the yield on a 20-year Government bond.

(3) k_4 is the CAPM equity cost with ex-ante measures of market risk premium.

Table A-19
Regression Results Based on the Gordon Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT) + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE
1977	0.3965 (2.57)	5.7790 (4.76)	-0.3188 (0.13)	-0.1226 (-1.66)	-0.0487 (-1.77)	-0.6001 (-0.85)	0.1249 (2.05)	0.4729	0.1073
1978	0.3070 (2.62)	5.0350 (5.57)	-0.7957 (-0.36)	-0.0480 (-0.70)	-0.0210 (-0.80)	0.1278 (0.20)	0.0188 (1.62)	0.3677	0.0977
1979	0.3652 (3.84)	3.7260 (5.23)	0.8456 (0.46)	-0.0263 (-0.52)	-0.0354 (-1.62)	-0.8577 (-1.51)	-0.0450 (-0.88)	0.4495	0.0785
1980	0.3255 (2.76)	3.7150 (4.20)	-0.3151 (-0.16)	-0.0502 (-0.98)	-0.0001 (-0.00)	-0.2642 (-0.42)	-0.0873 (-1.40)	0.2771	0.0951
1981	0.2432 (2.15)	4.7070 (5.93)	-0.6273 (-0.37)	-0.0603 (-1.50)	-0.0324 (-1.10)	-0.1594 (-0.28)	-0.0199 (-0.35)	0.4146	0.0849

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the normalized rate of return, NROE.

(3) Equity risk measured as standard deviation of return on equity, SROE.

Table A-20
Regression Results Based on the Gordon Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT) + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE
1977	0.4638 (4.56)	4.5410 (6.43)	-0.0119 (-0.44)	-0.1373 (-2.03)	-0.0405 (-1.57)	-1.5210 (-2.60)	0.1648 (2.99)	0.5685	0.0971
1978	0.3370 (4.27)	4.2430 (7.54)	-0.0199 (-0.87)	-0.1077 (-1.75)	-0.0015 (-0.17)	-0.6139 (-0.69)	0.1033 (2.10)	0.4971	0.0871
1979	0.4082 (5.87)	3.2500 (6.58)	-0.0552 (-2.68)	-0.0855 (-1.77)	-0.0050 (-0.66)	-1.953 (-2.55)	-0.0212 (-0.45)	0.5340	0.0722
1980	0.3167 (3.25)	3.4930 (5.21)	-0.0480 (-1.98)	-0.0961 (-1.92)	-0.0178 (0.58)	-0.5809 (-0.87)	-0.0618 (-1.02)	0.3455	0.0949
1981	0.2656 (2.74)	4.2180 (6.24)	-0.0511 (-2.29)	-0.0929 (-2.32)	-0.0226 (-0.78)	-0.7123 (-1.38)	-0.0167 (0.29)	0.4361	0.0833

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the projected rate of return, PROE.

(3) Equity risk measured as accounting ROE beta, BROE.

Table A-21
Regression Results Based on the Gordon Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT) + a_5(\Delta ROE)_i + a_6(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	a_6	R^2	SEE
1977	0.4331 (4.00)	4.6360 (6.63)	1.4360 (0.62)	-0.1347 (-2.03)	-0.0433 (-1.74)	-1.4110 (-2.71)	0.1572 (2.89)	0.5696	0.0969
1978	0.3460 (4.09)	4.2480 (7.51)	-0.0683 (-0.34)	-0.0947 (-1.55)	-0.0757 (-0.33)	-0.3620 (-0.70)	0.0964 (1.98)	0.4927	0.0875
1979	0.4250 (5.63)	3.0200 (5.93)	0.8771 (0.52)	-0.0539 (-1.10)	-0.0136 (-0.66)	-1.4070 (-2.85)	-0.0427 (-0.87)	0.4892	0.0756
1980	0.3786 (4.00)	2.9490 (4.70)	0.8521 (0.43)	-0.0674 (-1.35)	0.0052 (0.18)	-0.3724 (-0.63)	-0.0847 (-1.39)	0.3116	0.0928
1981	0.3304 (3.22)	3.5820 (5.72)	1.6450 (0.90)	-0.0761 (-1.88)	-0.0007 (-0.02)	-0.3624 (-0.64)	-0.0131 (-0.23)	0.4016	0.0858

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the projected rate of return, PROE.

(3) Equity risk measured as standard deviation of return on equity, SROE.

Table A-22
Regression Results Based on the Gordon Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT) + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE
1977	0.2886 (2.53)	6.3450 (6.96)	-0.0298 (-1.05)	-0.1708 (-2.28)	-0.0081 (-0.27)	0.1835 (3.00)	0.4630	0.1083
1978	0.1995 (1.70)	5.8650 (6.01)	-0.0479 (-1.91)	-0.1584 (-2.27)	0.0058 (0.22)	0.1439 (2.58)	0.3496	0.0991
1979	0.3343 (2.07)	4.2480 (3.10)	-0.0148 (-0.55)	-0.1296 (-2.06)	0.5055 (0.10)	-0.0670 (-1.06)	0.1653	0.0996
1980	-0.3266 (-1.51)	9.4150 (5.20)	-0.0304 (-1.30)	-0.0772 (-1.50)	-0.0101 (-0.35)	-0.0101 (-0.35)	0.3112	0.0928
1981	0.0395 (0.22)	6.1830 (4.53)	0.0094 (0.44)	-0.1370 (-2.93)	-0.0201 (0.59)	0.0201 (0.59)	0.2733	0.0945

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the instrumental variable rate of return, IVROE.

(3) Equity risk measured as accounting ROE beta, BROE.

Table A-23
Regression Results Based on the Gordon
Valuation Equation Model, 1977-1981

Model: M3

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + a_3(AFUDC/NI)_i + a_4(FT) + a_5(NUK)_i + U_i$

Sample: 79 electric utilities

Year	a_0	a_1	a_2	a_3	a_4	a_5	R^2	SEE
1977	0.3117 (2.66)	6.0950 (6.92)	1.0440 (0.40)	-0.1585 (-3.14)	-0.0174 (-0.62)	0.1684 (2.77)	0.4562	0.1090
1978	0.3216 (2.81)	5.0700 (5.56)	-1.5840 (-0.69)	-0.1145 (-1.65)	-0.0080 (-0.30)	0.1182 (2.14)	0.3216	0.1012
1979	0.3735 (2.49)	3.8950 (3.22)	0.1801 (0.08)	-0.1163 (-2.00)	-0.0004 (-0.02)	-0.0744 (-1.20)	0.1620	0.0970
1980	-0.2348 (-1.16)	8.5160 (5.11)	1.1760 (0.61)	-0.0593 (-1.19)	-0.0189 (-0.66)	-0.0699 (-1.14)	0.2988	0.0940
1981	-0.0566 (-0.32)	6.7020 (5.11)	1.9370 (1.03)	-0.1496 (-3.37)	0.0124 (0.72)	-0.0325 (-0.52)	0.2818	0.0940

Notes: (1) Figures in parentheses are t values.

(2) Expected return on equity, EROE, measured as the instrumental variable rate of return, IVROE.

(3) Equity risk measured as standard deviation of return on equity, SROE.

Table A-24
List of Fortune 26 Companies

1. Beatrice Foods Company
2. Caterpillar Tractor Company
3. Coca-Cola Company
4. Colgate-Palmolive Company
5. Dart & Kraft Industries, Inc.
6. Deere & Company
7. Du Pont (E.I.) de Nemours & Company
8. Eastman Kodak Company
9. General Electric Company
10. General Foods Corporation
11. General Motors Corporation
12. IBM Corporation
13. International Paper Company
14. Johnson & Johnson
15. Minnesota Mining & Manufacturing Company
16. Monsanto Company
17. Nabisco Brands, Inc.
18. Pepsico, Inc.
19. Proctor & Gamble Company
20. Ralston Purina Company
21. Raytheon Company
22. Reynolds (R.J.) Industries, Inc.
23. Rockwell International Corporation
24. Union Carbide Corporation
25. United Technologies Corporation
26. Xerox Corporation

Table A-25
Sample of Telephone Companies Used in the Regression Analysis

1. Allied Telephones
2. Centel Corporation
3. Cincinnati Bell, Inc.
4. Continental Telecommunications, Inc.
5. General Telephone & Electronics.
6. Mid-Continental Telephone
7. Rochester Telephone Company
8. Southern New England Telephone
9. United Telecommunications

Table A-26
Regression Results Based on the Gordon Model, 1977-1981

Model: M4

Regression: $(P/B)_i = a_0 + a_1(EROE)_i + a_2(\text{equity risk})_i + U_i$

Sample: 9 telephone companies

Year	a_0	a_1	a_2	R^2	SEE
1977	0.4153 (1.71)	5.8230 (2.87)	-0.0211 (-0.21)	0.6004	0.1311
1978	0.3845 (1.39)	5.0870 (2.36)	-0.0759 (0.75)	0.4810	0.1325
1979	0.2472 (0.79)	6.4330 (2.62)	-0.2071 (-1.60)	0.5410	0.1467
1980	0.4519 (1.47)	4.5870 (1.97)	-0.2486 (-2.21)	0.5124	0.1254
1981	-0.2078 (-0.40)	9.984 (2.75)	-0.2697 (-1.91)	0.5992	0.1613

Notes: (1) Figures in parentheses are t values.

(2) Expected rate of return on equity, EROE, measured as the projected rate, PROE.

(3) Equity risk measured as accounting ROE beta.

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BIOGRAPHICAL SKETCH

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I certify that I have read this study and that in my opinion it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a dissertation for the degree of Doctor of Philosophy.

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